2168A

Multitype Digital Thermometer

Instruction Manual

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FLUKE®

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John Fluke Mfg. Co., Inc., P.O. Box C9090, Everett, Washington 98206

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Introduction & Specifications

1-1. INTRODUCTION

1-2. The Model 2168A Multitype Digital Thermometer is a portable four-digit, thermocouple thermometer capable of utilizing any one of eight thermocouple types as an input, and resolving 1°C or 1°F over a temperature range of −200 to +2328°C or −328 to +3999°F. It features switch selection of temperature scale (°C or °F) and of thermocouple type (J, K, T, E, R, S, B or C), a four-digit LED display, reference junction compensation (to eliminate the need for an ice bath reference junction), dual-slope measurement techniques, digital linearization for the selected thermocouple type, and power inputs for both ac line and external 12V dc operation.

1-3. Front panel switch controls include a push-button power switch (ON/OFF), a push-button temperature scale switch (°C/°F), and an eight-position rotary switch for selecting the desired thermocouple type. The rotary switch positions are J, K, E, T, R, S, B and C.

1-4. The front-panel display consists of five, seven-segment, high-intensity LED's, and features leading zero suppression. Four of the LED's are used to display numeric data, including a minus sign for negative temperature indications. The fifth LED displays the selected °C or °F scale character. An open thermocouple detector causes the display to blink when an open circuit is sensed at the thermocouple input terminals.

1-5. Rear-panel, screw-type input connectors are provided for attaching the selected thermocouple. These terminals are an integral part of an isothermal block, and serve as the reference junction for the reference-junction compensator. (The reference-junction compensator provides the physical and electrical equivalent of, and eliminates the need for an ice bath reference junction at 0°C or 32°F.)

1-6. The actual thermocouple range of the 2168A is determined by the type of thermocouple being used as the input device; J, K, T, E, R, S, B or C. To ensure the proper linearization of the input thermocouple, the front-panel THERMOCOUPLE TYPE switch must be set to the corresponding type setting.

1-7. Accessories and Options available for use with the 2168A are listed and described in Table 1-1 and 1-2, respectively. All of the options and accessories described are field installable. However, only one of the options (−02 or −04) can be installed in the 2168A at any given time. Detailed information concerning each option and accessory is given in Section 6 of this manual, Option and Accessory Information.

Table 1-1. 2168A ACCESSORIES

MODEL NO.	DESCRIPTION
C80	Carrying Case
C86	Carrying Case
P20J	J-Type Thermocouple Probe
P20K	K-Type Thermocouple Probe
P20T	T-Type Thermocouple Probe
M00-100-714	Front Panel Dust Cover
M00-200-611	Rack Mounting Kit, Offset
M00-200-612	Rack Mounting Kit, Center
M00-200-613	Rack Mounting Kit, Side-by-Side
2160A-7022	Interface Cable

Table 1-2. 2168A OPTIONS

OPTION NUMBER	DESCRIPTION
−02	Digital Output Unit
−04	Analog Output Unit

1-8. The 2168A is designed to operate from either ac line power or an external 12V dc source. A choice of any one of three line power configurations are available: 100V ac, 50 to 440 Hz; 115V ac, 50 to 440 Hz; and 230V ac, 50 to 440 Hz. Specify the required configuration at the time of purchase.

1-9. SPECIFICATIONS

1-10. Specifications for the 2168A are given in Table 1-3.

Table 1-3. SPECIFICATIONS

ELECTRICAL

Compatible Thermocouple Types	J, K, T, E, R, S, B and C. Switch selectable
Measurement Method	Dual-slope integration over a 100 ms period
Zero Drift	None. Automatic zero correction
Reading Rate	2.5 readings per second
°C to °F Conversion	Switch selectable
Input Characteristics	
Input Connections	Screw terminals on isothermal connector
Input Circuit	Two-wire, isolated
Input Impedance	>100MΩ
Input Current	<500 pA
Source Impedance	≤5kΩ. 5kΩ causes < 0.2°C (.36°F) with K thermocouple
Overload	Display flashes when input voltage exceeds full-scale temperature range
Open Input	Display flashes to indicate open at input terminals
Maximum Input Voltage (without damage)	400V dc or ac peak continuously between inputs or between either input and ground
Maximum Common Mode Voltage (without damage)	400V dc or ac peak
Common Mode Rejection	⩾ 120 dB @ 50, 60, 400 Hz ±0.1% with 1kΩ source impedance unbalance
Normal Mode Rejection	⩾ 60 dB @ 50, 60, 400 Hz ±0.1%
Accuracy	See Table 1 for °C specifications and Table 2 for °F specifications
Response Time to Rated Accuracy	< 2.0 seconds
Linearization	Digital with eight selectable programs in LSI ROM
Linearization Programs	
J, K, T and E	32 straight line segments for positive inputs and 16 for negative inputs
R, S, B and C	48 straight line segments for positive inputs

Table 1-3. SPECIFICATIONS (Cont.)

Reference Junction Compensation

20 to 30°C (68 to 86°F)

J, K, T, E	0.025 degrees per degree
R, S	0.05 degrees per degree
C	0.02 degrees per degree

0 to 20°C, 30 to 50°C (32 to 68°F, 86 to 122°F)

J, K	0.032 degrees per degree
T, E	0.045 degrees per degree
R, S	0.07 degrees per degree
C	0.04 degrees per degree

Temperature Coefficient . . . . . 0.005% of reading per °C. For B thermocouples only, zero shift = 0.05 degrees per degree.

Internal Temperature Rise . . . . . ≤ 8°C (14.4°F)

Table 1 ACCURACY SPECIFICATIONS °C

THERMOCOUPLE TYPE	TEMPERATURE RANGE °C	RESOLUTION AND REPEATABILITY (±°C)	APPLICABLE TEMPERATURE RANGE °C	MAXIMUM ERROR INCLUDING NBS CONFORMITY (±°C)*				NBS CONFORMITY (±°C)
				CALIBRATION ACCURACY	20 min. to 24 hrs. 23 to 27°C	90 Days 20 to 30°C	1 Year 15 to 35°C	
J	−200 to 778	1	−200 to 0 0 to 778	1 1	1 1	1.5 1	1.5 1.5	.19 .15
K	−200 to 1356	1	−200 to 0 0 to 1356	1 1	1 1	1.5 1.5	2 2	.20 .18
T	−200 to 400	1	−200 to 0 0 to 400	1 1	1 1	1.5 1	2 1	.19 .15
E	−200 to 1000	1	−200 to 0 0 to 1000	1 1	1 1	1.5 1	2 1.5	.17 .18
R	0 to 1778	1	0 to 1778	1.5	1.5	2.5	3	.26
S	0 to 1778	1	0 to 1778	1.5	1.5	2	3	.22
B	533 to 1844	1	533 to 1844	1.5	1.5	2	2.5	.29
C	0 to 2328	1	0 to 2328	2	2	3	3	.36

* Includes reference junction and conformity errors. Excludes thermocouple errors.

Table 1-3. SPECIFICATIONS (Cont.)

Table 2 ACCURACY SPECIFICATIONS °F

THERMOCOUPLE TYPE	TEMPERATURE RANGE °F	RESOLUTION AND REPEATABILITY (±°F)	APPLICABLE TEMPERATURE RANGE °F	MAXIMUM ERROR INCLUDING NBS CONFORMITY (±°F)*				NBS CONFORMITY (±°F)
				CALIBRATION ACCURACY	20 min. to 24 hrs. 72 to 82°F	90 Days 68 to 86°F	1 Year 59 to 95°F	
J	–328 to 1432	1	–328 to 32 32 to 1432	1.5 1	1.5 1	2 1.5	2.5 2	0.27 0.2
K	–328 to 2472	1	–328 to 32 32 to 2472	2 1.5	2 1.5	2.5 2.5	3 3	0.28 0.26
T	–328 to 752	1	–328 to 32 32 to 752	1.5 1	1.5 1	2 1.5	3.5 2	0.3 0.2
E	–328 to 1832	1	–328 to 32 32 to 1832	1.5 1	1.5 1.5	2 2	3.5 2.5	0.25 0.25
R	32 to 3232	1	32 to 3232	2	2.5	4	5	0.4
S	32 to 3232	1	32 to 3232	2	2.5	3.5	4.5	0.33
B	992 to 3352	1	992 to 3352	2	2.5	3.5	4.5	0.45
C	32 to 3999	1	32 to 3999	3	3	5	5.5	0.58

*Includes reference junction and conformity errors. Excludes thermocouple errors.

GENERAL

Type of Display . . . . . LED, 0.56 in high. 3 lbs. (1.36 kg)

Power Requirements

Line Operation . . . . . 115V ac ±10%, 50 to 440 Hz, 8W. 100V ac and 230V ac version are also available

External DC Source . . . . . 11 to 15V dc @ 400 mA

Size . . . . . 2.52 in (H) x 8.55 in (W) x 9.9 in (D) (6.40 cm x 21,72 cm x 25,15 cm) See Figure 1-1.

Weight . . . . . 3 pounds (1.35 kg)

ENVIRONMENTAL

Temperature

Operating . . . . . 0 to 50°C (32 to +122°F)

Storage . . . . . –40 to 75°C (–40 to 167°F)

Humidity

0 to 50°C (32 to 122°F) . . . . . 80% non-condensing

0 to 35°C (32 to 95°F) . . . . . 90% non-condensing

Shock and Vibration . . . . . Meets requirements of MIL Standard 810

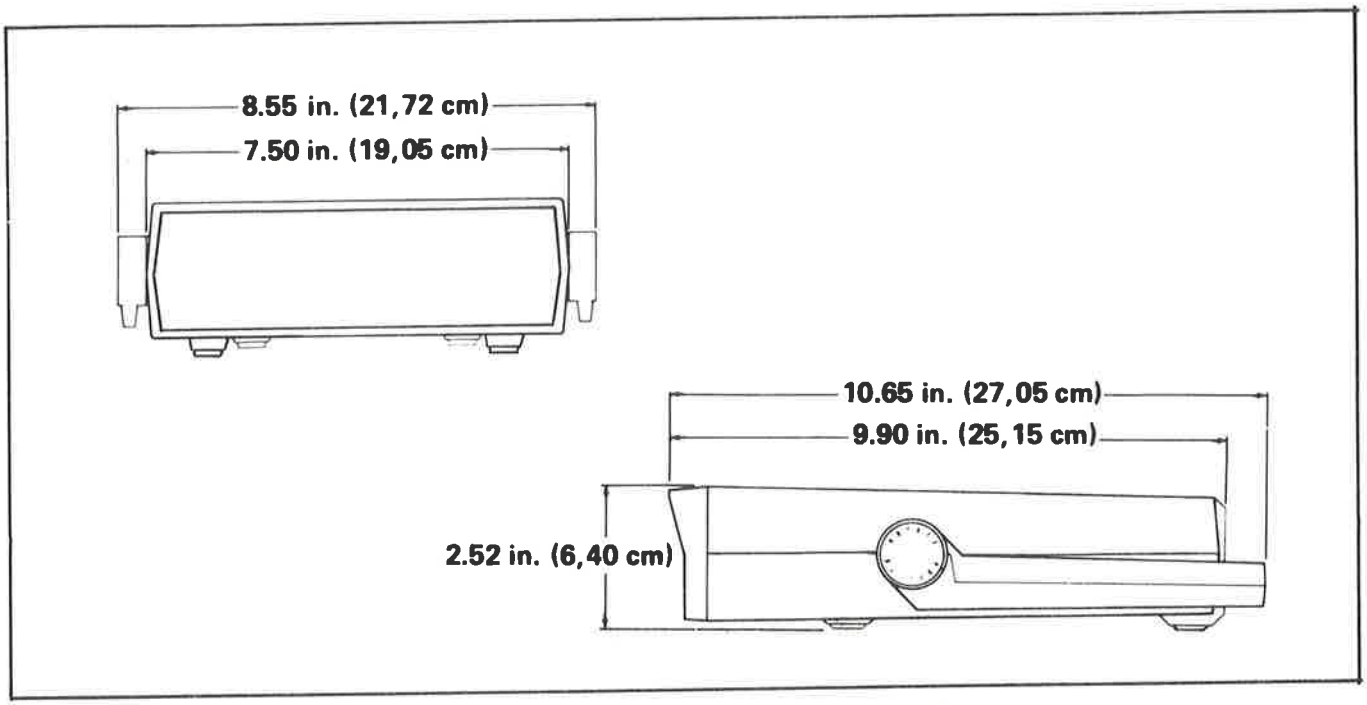


Figure 1-1. 2168A OUTLINE DRAWING

Section 2
Operating Instructions

WARNING!

Due to the possible presence of lethal voltages, the procedure in paragraph 2-21 should be performed by qualified personnel only.

2-1. INTRODUCTION

2-2. This section of the manual contains information regarding installation and operation of the Model 2168A Multitype Digital Thermometer. It is recommended that the contents of this section be read and understood before any attempt is made to operate the instrument. Should any difficulties arise during operation, please contact your nearest Fluke Technical Service Center, or the John Fluke Mfg. Co. Inc., P.O. Box 43210, Mountlake Terrace, WA, 98043, Tel. (206) 774-2211. A list of Technical Service Centers is located in Section 7 of this manual.

2-3. SHIPPING INFORMATION

2-4. The 2168A is packaged and shipped in a foam-packed container. Upon receipt of the instrument, a thorough inspection should be made to reveal any possible shipping damage. Special instructions for inspection and claims are included in the shipping carton.

2-5. If reshipment of the instrument is necessary, the original container should be used. If the original container is not available, a new one can be obtained from the John Fluke Mfg. Co., Inc. Please reference the instrument model number when requesting a new shipping container.

2-6. INPUT POWER

2-7. The 2168A can be operated from either ac line power or an external 12V dc source. The unit is energized when either or both sources are connected to their proper input terminals, and the front-panel POWER switch is set to ON.

2-8. AC Line Voltage

2-9. The 2168A is factory wired to operate from one of three ac line voltages. These are: 100V ac, 50 to 440 Hz; 115V ac, 50 to 440 Hz; and 230V ac, 50 to 440 Hz. Before connecting the 2168A to the ac line, check to ensure that the instrument is wired to accommodate the local line voltage. A decal on the underside of the unit defines the particular line voltage required to operate the instrument.

2-10. The rear panel ac input connector is a three-prong, U-ground connector which permits the instrument to be connected, via the power cord, to the appropriate line voltage. The offset prong on this connector is connected to the 2168A power supply, and should be connected through the power cord to a high quality earth ground.

2-11. External 12V dc Source

2-12. The external 12V dc source connects to two screw terminals provided on the rear of the 2168A. The decal on the bottom of the unit defines their location and polarity. The external source should be capable of supplying at least 400 mA at 11V dc.

2-13. RACK INSTALLATION

2-14. The 2168A is designed for field and bench-top use or for installation in a standard 19-inch equipment rack using

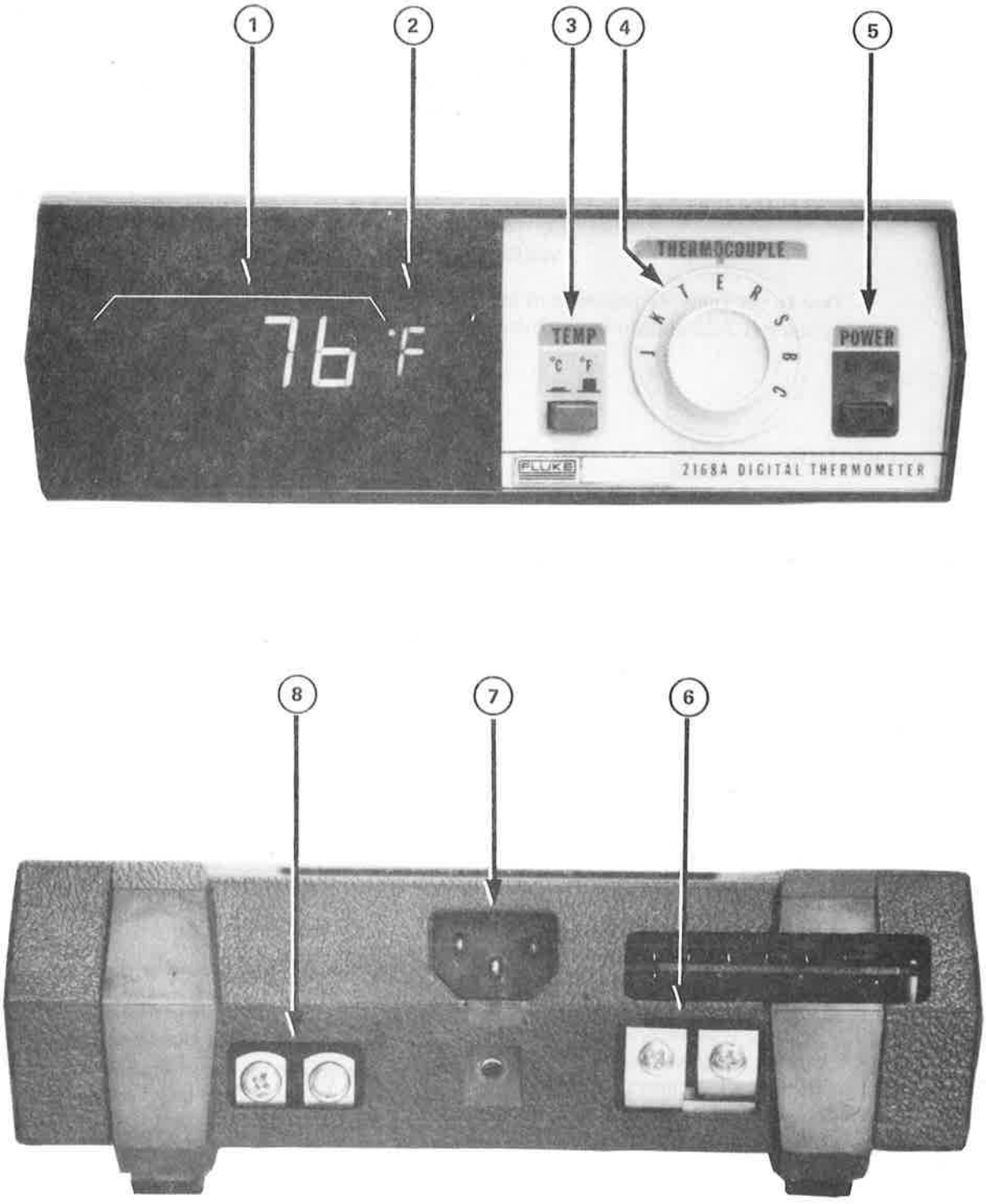


Figure 2-1. 2168A CONTROLS, INDICATORS & CONNECTORS

an accessory rack-mounting kit. Kits are available for left, right, center or side-by-side mounting of the 2168A. Information regarding installation of the rack mounting accessories is given in Section 6 of this manual, Option and Accessory Information.

2-15. OPERATING FEATURES

2-16. The locations of all 2168A controls, indicators and connectors are shown in Figure 2-1, and described in Table 2-1.

2-17. OPERATING NOTES

2-18. The following paragraphs describe various conditions which should be considered before operating the 2168A.

2-19. Option Information

2-20. Supplementary operating instructions are necessary when operating a 2168A which is equipped with one of the available options. Detailed information regarding the operation of each available option is given in Section 6 of this manual, Option and Accessory Information.

2-21. Fuse Replacement

WARNING!

Disconnect the unit from line power before attempting to replace the fuse.

2-22. The ac line-input section of the 2168A power supply is fuse protected. The fuse is located on the interior of the unit near the power transformer. To access the fuse, remove the rear-panel retaining screw located beneath the ac line connector, and pull the case from the instrument. When replacement is necessary, use a MDL (Slo-blo) 1/8A fuse.

2-23. Overload and Open Thermocouple Indication

2-24. The front panel display, in addition to providing a measurement reading, is designed to serve as an overrange or open thermocouple indicator. When the measurement range of the input thermocouple is exceeded, or when the thermocouple inputs are open circuited, the display will blink. The blinking indication does not mean that the instrument is being exposed to a damaging input condition.

Table 2-1. 2168A CONTROLS, INDICATORS AND CONNECTORS

REF. NO.	NAME	FUNCTION
1	Digital Display	Displays a four digit readout of the measured input temperature. Leading-zero suppression is included. A minus sign is displayed for negative temperature measurements. The absence of a polarity sign indicates a positive temperature measurement.
2	Temperature Scale Indicator	Displays the temperature scale represented by the digital display; °C or °F.
3	TEMP Scale Select Switch	Selects the temperature scale for the digital display. When the switch is depressed (IN), the °C scale if selected. The °F scale is selected when the switch is released (OUT).
4	Thermocouple Type Select Switch	Selects one of eight thermocouple types (J, K, T, E, R, S, B or C) to be used as the thermometer input device. The temperature of the selected thermocouple is continuously read and displayed.
5	POWER Switch	Switches the 2168A on or off regardless of the input power source. The instrument is turned on when the switch is depressed.
6	Thermocouple Input Connections	Provides screw-type input terminals for connecting the thermocouple to the thermometer.
7	Input Power Connector	Provides the means of connecting the instrument through the power cord to ac line power. Line power is not required when the unit is being operated from an external 12V dc source.
8	External 12V dc Input Connections	Provides screw-type input terminals for connecting an external 12V dc source. The 12V dc connections are not required when the unit is being operated from ac line power.

2-25. OPERATION

2-26. With reference to previous paragraphs in this section, use the following procedure to operate the 2168A:

a. Refer to the decal on the bottom of the unit and connect one of the listed thermocouple types (J, K, T, E, R, S, B or C) to the rear-panel thermocouple input connections.

b. Connect the unit to the appropriate line power as defined on the bottom decal.

c. Energize the unit by depressing the power switch.

d. Set the TYPE SELECT switch to correspond with the attached thermocouple type.

e. Set the TEMP switch to the desired temperature scale, °C or °F.

f. Refer to Section 6 of this manual for instructions concerning the operation of the –02 and –04 Options.

g. Expose the thermocouple probe to a temperature within its specified range (see bottom decal). The probe temperature will be displayed on the front panel.

Section 3
Theory of Operation

3-1. INTRODUCTION

3-2. This section of the manual contains an overall functional description followed by a circuit analysis of the 2168A. Simplified circuit diagrams and timing diagrams are included, as necessary, to supplement the text. Detailed schematics are given in Section 8 of this manual.

3-3. OVERALL FUNCTIONAL DESCRIPTION

3-4. The Model 2168A Multitype Digital Thermometer, as shown in Figure 3-1, is a portable four-digit, thermocouple thermometer capable of utilizing any one of eight thermocouple types as an input, and resolving 1°C or 1°F over a temperature range of –200 to +2328°C or –328 to +3999°F. It features switch selection of temperature scale (°C/°F) and of thermocouple type (J, K, T, E, R, S, B or C), a reference junction compensator (to eliminate the need for an ice bath reference junction), dual-slope integration, LSI digital control logic (includes linearization programs for eight thermocouple types), a four-digit LED display, and power inputs for both ac line and external 12V dc operation.

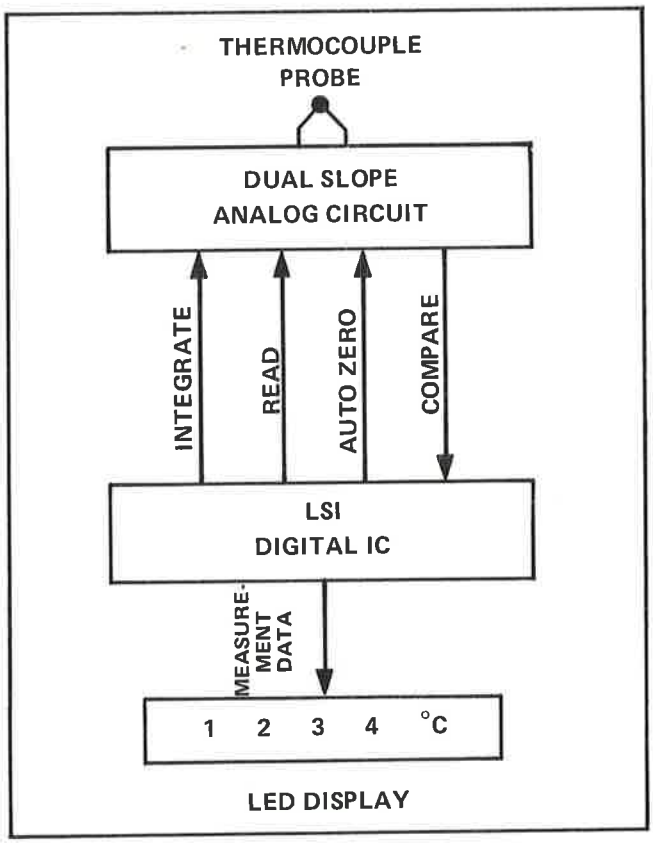


Figure 3-1. 2168A SIMPLIFIED BLOCK DIAGRAM

3-5. In operation, the 2168A executes a continuous series of measurement cycles to update the temperature display. The measurement cycle is controlled entirely by an LSI digital IC, and includes three major subcycles; Auto-Zero period, Integrate period and Read period. Each subcycle controls the operation of the analog section of a dual-slope integrator which, in turn, generates a compare output to control the digital conversion performed by the LSI digital IC.

3-6. The configuration of the analog section of the 2168A, during each phase of the measurement cycle, is established by a combination of FET switches that are controlled by the LSI digital IC. The measurement cycle begins with the Auto-Zero period. During this period, the reference junction compensation voltage and the accumulated dc offset voltages present in the analog section are sampled and held by capacitors. These voltages are used later in the measurement cycle to cancel measurement errors introduced by offset voltages and reference junction voltage errors created at the input terminal connections. As a result, the final measurement is proportional to the thermocouple probe output voltage and does not include offset errors or reference junction voltage errors. During the Integrate period, the thermocouple input

voltages (probe voltage and input terminal voltages) are applied to the integrator, and the algebraic sum of these voltages is integrated over a 100 ms period. At the end of this period, the thermocouple input voltages are removed from the integrator and the Read period is started. A reference voltage is applied to the integrator during the Read period causing the integrator capacitor to be discharged at a linear rate. When the integrator output reaches zero, a compare signal is generated to end the Read period. The duration of the Read period is translated by the LSI digital IC to provide a digital indication proportional to the thermocouple probe temperature.

3-7. CIRCUIT ANALYSIS

3-8. Circuit analysis of the 2168A is discussed in two sections; digital and analog. The digital section is covered first, and particular attention is paid to the control it exercises on the analog section. The analysis of the analog section covers the analog measurement circuitry and the 2168A power supply.

3-9. Digital Section

3-10. The digital section of the 2168A consists of an LSI digital IC, a hex buffer, a seven-segment decoder/driver and an LED display. Its function is to convert the non-linear thermocouple probe voltage, as measured by the analog section, into a linear digital display. The display provides a direct reading of probe temperature in °C or °F.

3-11. The LSI digital IC contains all of the 2168A control logic and linearizing capability, and provides the hex buffer and seven-segment decoder with the data necessary to update the LED display. The linearization of the nonlinear input signal is accomplished by selecting one of eight programs which vary the rate at which the measurement counts are accumulated. The program is selected by the front-panel TYPE SELECT switch, and is matched with the thermocouple probe type.

3-12. Measurement data is continuously strobed out of the LSI digital IC in bcd, character-serial format. At the end of each measurement cycle, an update flag is raised to signify that a new reading is available. When an overload occurs, the number of accumulated counts are stored and presented, along with a blanking pulse, as output data. The blanking pulse alternately turns the display on and off to indicate the presence of an overload.

3-13. The basic measurement cycle, as shown in Figure 3-2, comprises three subcycles; a 100 ms minimum Auto-

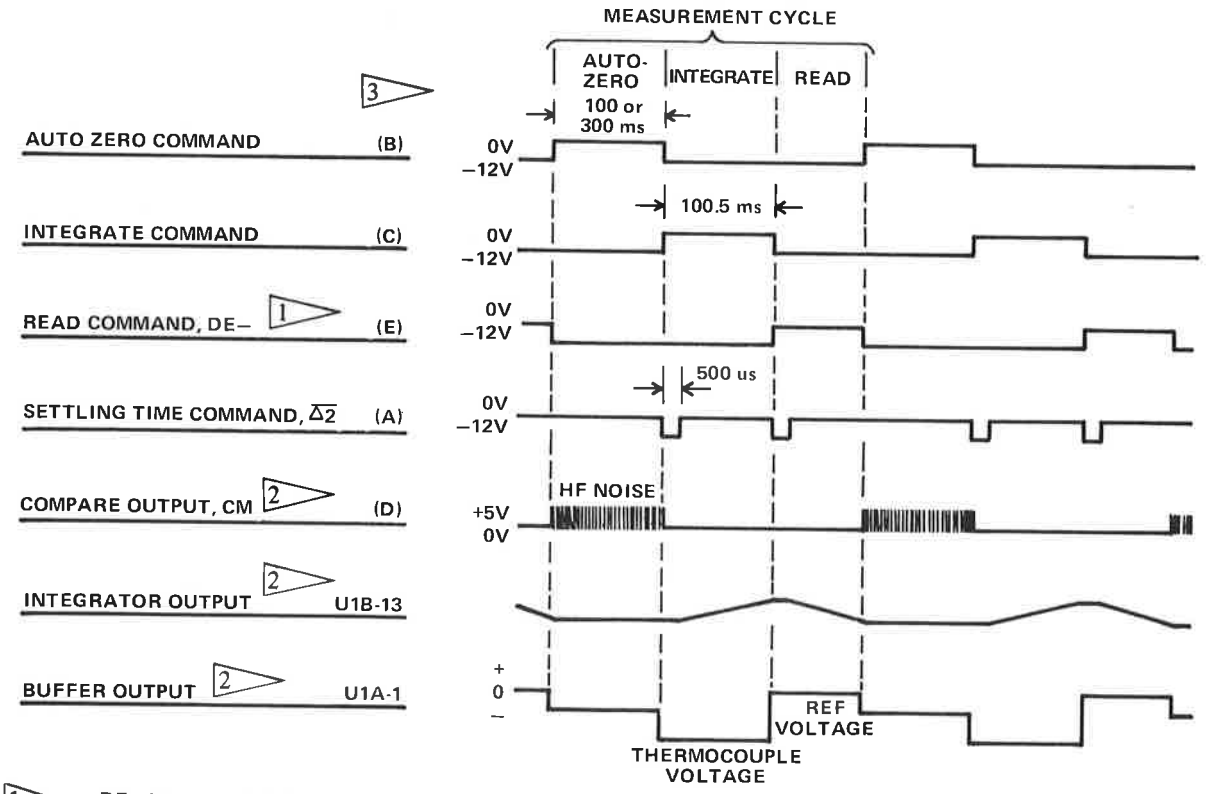


Figure 3-2. MEASUREMENT CYCLE WAVEFORMS

Zero period, a 100 ms Integrate period, and a variable Read period. The auto-zero period is extended to 300 ms when an overload occurs. To accommodate settling times in the analog section, a 500 us hold signal is inserted at the beginning and at the end of the Integrate period.

3-14. Analog Section

3-15. ANALOG MEASUREMENT CIRCUIT

3-16. The analog measurement circuit is shown in simplified form in Figure 3-3. It consists of a thermocouple input circuit, a reference-junction compensator, a voltage reference, a Buffer Amplifier, an Integrator, a Comparator, and a combination of FET switches. The switches are shown in their open state and are closed by the measurement cycle commands generated by the LSI digital IC. Each switch is assigned a letter designation which corresponds to a measurement cycle command shown in Figure 3-2.

3-17. The Thermocouple Input circuit consists of an R-C filter and a pair of voltage protection diodes. The difference between the thermocouple probe voltage and the input terminal voltage is passed through the filter and appears at the arm of switch C.

3-18. The Reference-Junction Compensator consists of an isothermal block, a pair of screw type input terminals, and a transistor temperature sensor. The isothermal block maintains a known temperature differential between the input terminals and the temperature sensing transistor. Thermocouple voltages introduced by the dissimilar metals at the input terminals vary as the isothermal block adjusts to ambient temperature. Temperature changes are sensed by the forward-biased transistor which produces a correction voltage equivalent to the thermocouple voltage created at the input terminals. Predictable characteristics of a forward-biased P-N junction allow the Reference-Junction Compensator to function over a wide temperature range. The correction voltage is matched to the thermocouple probe type by an Offset Resistor which is selected by the front-panel TYPE SELECT switch. The correction voltage appears at the arm of switch B1.

3-19. The voltage reference consists of a resistor divider which is supplied by an accurate 6.4V dc reference voltage. The divider is calibrated to match the thermocouple probe type by a Full-Scale Resistor which is selected by the TYPE SELECT switch. Two voltages are available at the divider outputs; 0.5 x V ref, and 1.5 x V ref. These voltages appear at the arms of switches B2 and E, respectively.

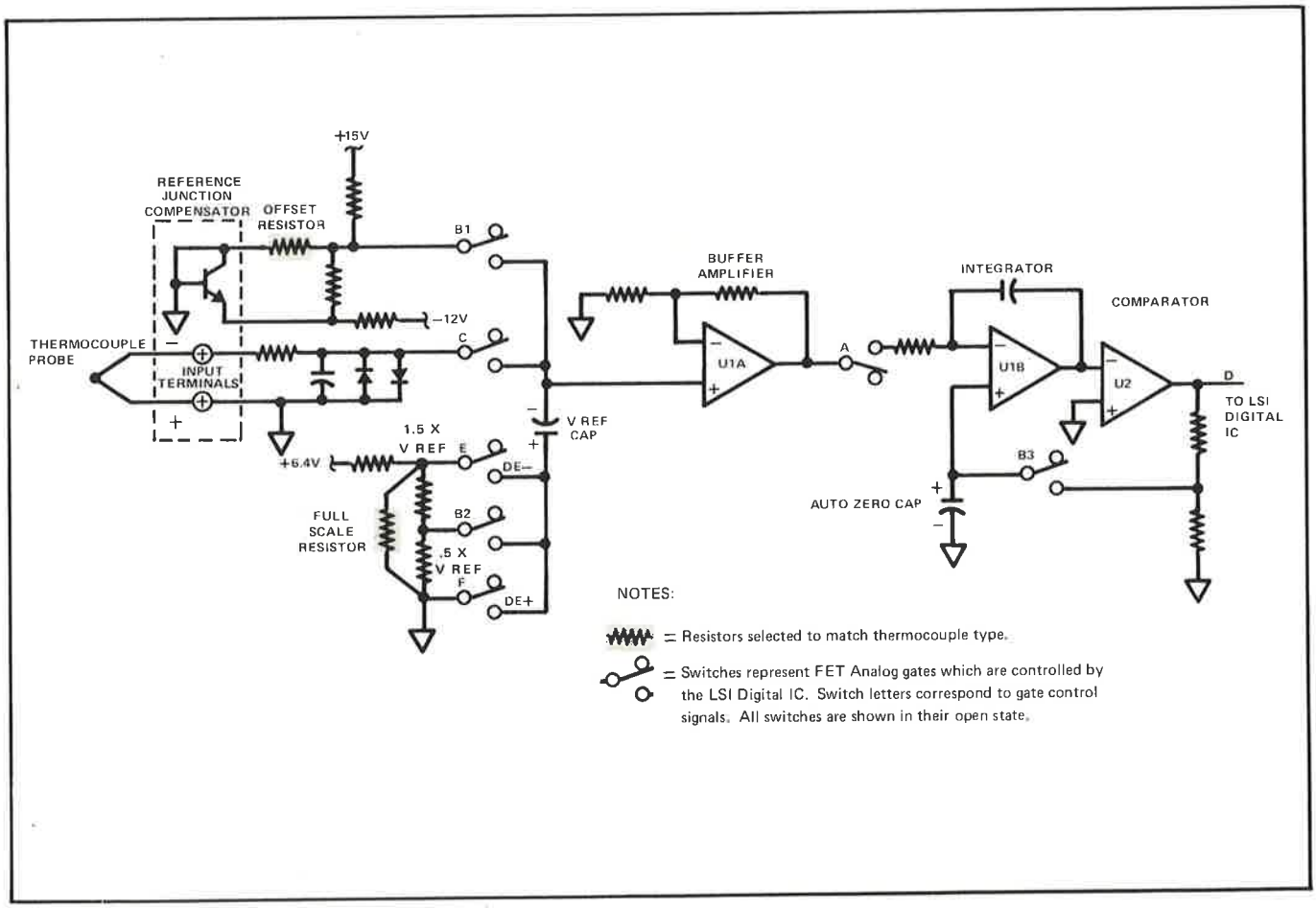


Figure 3-3. ANALOG SECTION, SIMPLIFIED CIRCUIT DIAGRAM

3-20. The Buffer, Integrator and Comparator amplifiers combine to perform the analog functions of the Integrate, Read and Auto-Zero periods. The Buffer is used to provide integrator inputs during all three periods. The Integrator integrates the Buffer output voltage during the Integrate and Read periods, and functions, in combination with the Comparator, as a closed-loop amplifier during the Auto-Zero period.

3-21. During the first phase of each measurement cycle, the analog section goes through an Auto-Zero period. During this time, three auto-zero switches (B1, B2 and B3) are closed by the Auto Zero command from the LSI digital IC. Two of the switches (B1 and B2) charge the V ref capacitor to a level equal to the algebraic sum of the 0.5 x V ref output, plus the correction voltage generated by the Reference-Junction Compensator. At the same time, the correction voltage is amplified by the Buffer Amplifier and presented through switch A to the Integrator input. The third switch (B3) connects the Integrator and Comparator in a closed loop configuration and allows the Auto-Zero capacitor to charge to a value which is proportional to the Reference-Junction-Compensator correction voltage plus the offset voltages present in the Buffer, Integrator and Comparator amplifiers. At the end of the measurement cycle switches B1, B2 and B3 are opened. The V ref capacitor and the Auto-Zero capacitor retain their charge for use later in the measurement cycle.

3-22. The Integrate period starts on the leading edge of the Integrate Command from the LSI digital IC; switch A is open and switch C is closed. The thermocouple input voltage is applied through switch C to the buffer input. After a 500 us settling period, switch A closes and the Buffer output voltage is applied to the Integrator input for 100 ms. As the integrator capacitor charges, the Integrator drives the Comparator output to either 0 or +5V dc to indicate the polarity of the thermocouple input voltage, positive or negative, respectively. The comparator output is sent to the LSI digital IC for use during the Read period. At the end of the Integrate period, the integrator capacitor is charged to a level and polarity that is proportional to the thermocouple probe voltage and switch C returns to its open state.

3-23. The Read period starts at the end of the Integrate period and one of two Read Modes is enabled depending upon the input polarity sensed by the comparator at the end of the Integrate period. If a positive input is sensed, a DE– Read Mode is enabled. Similarly a DE+ Read Mode is enabled when a negative input is sensed.

3-24. If the DE– Read Mode is commanded, switch A is opened and E is closed. Switch E applies a 1.5 x V ref input to the positive side of the V ref capacitor. This voltage is algebraically added to the voltage stored in the V ref capacitor during the previous Auto-Zero period (0.5 x V ref + Reference-Junction-Compensator voltage). As a result, the input to the Buffer Amplifier is a positive voltage equal to V ref plus the Reference Junction-Compensator voltage.

3-25. If the DE+ Read Mode is commanded, switch A is opened and F is closed. Switch F grounds the positive side of the V ref capacitor and causes the Buffer amplifier input to be driven to the voltage stored in the V ref capacitor during the previous Auto-Zero period (0.5 x V ref + Reference-Junction Compensator voltage). As a result, the input to the Buffer Amplifier is a negative voltage equal to 0.5 x V ref plus the Reference-Junction-Compensator voltage.

3-26. After a 500 us settling time, switch A closes and the Buffer output voltage is applied to the Integrator input. This causes the integrator capacitor to discharge at a linear rate determined by the reference voltage. The discharge continues until the integrator output voltage reaches zero volts, the level existing prior to the integrate period. This level is sensed by the Comparator which signals the LSI digital IC to terminate the A/D conversion of measurement data.

3-27. Offset voltages present during the Integrate and Read periods are cancelled out by offset voltages that were sampled and held during the Auto-Zero period. However, the Reference-Junction-Compensator voltage (also sampled and held during Auto Zero) is added to the integrator voltage during the Integrate period. As a result, the displayed temperature is equal to the thermocouple probe temperature.

3-28. POWER SUPPLY

3-29. The 2168A power supply consists of a power transformer, fuse, power input connector, a dc-to-dc converter, and associated regulating circuits. The function of the power supply is to provide the unit with the necessary operating voltages during both external battery (12V dc) and ac line operation. Operating voltages include: +5, +6.8, +15 and –12V dc. All voltages are regulated. During line operation, an addidtional +5V ac (rms) source is available for use by ground-isolated output options (–02 and –04).

NOTE

The –02 and –04 output options are functional only when the unit is operated from the ac line.

3-30. The dc-to-dc converter is energized by a +9.6V dc input which is derived from either the power transformer during line operation, or the external dc source. Conventional regulating and isolating techniques produce +6.8, +15, –12 and +5V dc operating voltages at the dc-to-dc converter output.

Section 4
Maintenance

WARNING!

THESE SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRIC SHOCK, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN THE OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.

4-1. INTRODUCTION

4-2. This section of the manual provides information about warranty, factory service, maintenance, performance testing, routine recalibration and recalibration after repair. The performance test is recommended when the instrument is received and later as a preventive maintenance tool or for testing after repair. The test verifies performance at several temperatures within the range of a given thermocouple type. Specifications are provided both for annual and for a more precise 90-day performance-testing cycle.

4-3. SERVICE INFORMATION

4-4. The instrument is warranted for a period of one year upon delivery to the original purchaser. The WARRANTY is located on the back of the title page located in the front of this manual.

4-5. Factory authorized calibration and service for each Fluke product is available at various world-wide locations. A complete list of these service centers is included in Section 7 of this manual. If requested, an estimate will be provided to the customer before any work is begun on instruments that are beyond the warranty period.

4-6. GENERAL MAINTENANCE

4-7. Access Information

4-8. Use the following procedure to gain access to the interior of the instrument:

a. Set the POWER switch to OFF and disconnect the ac and 12V dc power cords from the unit.

b. Disconnect the thermocouple probe at the input terminals.

c. Remove the phillips-head screw located in the center of the rear panel.

d. Pull the instrument out of the front of the case.

4-9. Cleaning

4-10. Clean the instrument periodically to remove dust, grease and other contamination. Use the following procedure:

CAUTION!

Do not use aromatic hydrocarbons or chlorinated solvents for cleaning. They will react with plastic materials used in manufacture of the instrument.

a. Clean the front panel and case with a soft cloth dampened with a mild solution of detergent and water.

b. Clean the surface of the pcb using clean dry air at low pressure ($\leq$20 psi). If grease is encountered, spray with Freon T. F. Degreaser or anhydrous alcohol and remove grime with clean dry air at low pressure.

4-11. Fuse Replacement

WARNING!

DISCONNECT THE UNIT FROM LINE POWER BEFORE ATTEMPTING FUSE REPLACEMENT.

4-12. The input power fuse is located on the interior of the unit near the ac line connector. If replacement is necessary, use an MDL (Slo-blo) 1/8A fuse.

4-13. Service Tools

4-14. No special tools are required for maintenance or repair.

4-15. PERFORMANCE TEST

4-16. Table 4-1 lists the equipment required for performance testing and recalibration. If the recommended model of test equipment is not available, a substitute that meets the minimum use specifications may be used. Table 4-2 outlines the Performance Test. A Performance Checklist at the end of this section may be reproduced or removed to provide a written record of results. The Performance Test verifies instrument performance to specifications for initial acceptance or for maintenance. (Periodic recalibration requires the calibration procedure beginning in paragraph 4-27). If the thermometer fails to meet specifications, it requires recalibration or repair. Review Table 4-2, then continue.

Table 4-1. TEST EQUIPMENT REQUIREMENTS

TEST EQUIPMENT	MINIMUM USE SPECIFICATIONS	RECOMMENDED MODEL
Thermocouple Probes	Type J, K, T, E, R, S or C (select type compatible with thermometer)	Omega TJ36 Series, Grounded Sheath
Mercury, thermometer (either °C or °F)	0.02°C Resolution 0.05°F Resolution	Princo Model ASTM-56C Princo Model ASTM-56F
Dewar Flask/Cap	1-pint capacity	Thermos
DC Voltage Calibrator	Output Voltage: 0 to 10V Accuracy: 0.002% Resolution: 10 mV	Fluke Model 343A
Voltage Divider 100:1 or Kelvin-Varley Divider (Shunt output with 1 uf capacitor)	Ratio: 0.005%	Fluke A21-5 or Fluke 720A or Fluke 750A
Variable Line-Voltage Transformer	100, 115, 230V ac, as required, ±10%	General Radio VARIAC W5HM
Decade Resistor	Accuracy: 1% Ranges: 1K, 10K and 100K	General Radio 1434

NOTE

The Performance Test should be conducted at an ambient temperature of 25 ± 2° C (77 ± 3.6° F).

4-17. Set-up Procedure

4-18. The following steps prepare for performance testing:

a. Remove the thermometer from its case.

b. Locate the RJD switch on the main pcb (See Figure 4-1) and set it to the RJD position. (This defeats the reference-junction circuitry.)

Table 4-2. PERFORMANCE TEST DESCRIPTION

TEST	PERFORMANCE SPECIFICATIONS	TEST METHOD	BEGINNING TEXT PARAGRAPH
Setup			4-17
Overload and Open Input Test	The display flashes to indicate both over range input voltages and open input terminals.	An over range voltage is applied to the thermocouple input terminals, and the input terminals are open circuited.	4-19
Line Voltage Regulation	Satisfactory performance with any line voltage within ±10% of nominal; 100, 115 or 230V ac	The display is monitored during the accuracy test as the line voltage is varied.	4-21
Accuracy Test	Temperature Accuracy as stated in Table 4-3	Known input voltages are substituted for the thermocouple inputs. Cardinal-point checks ensure accuracy over the entire temperature range.	4-23
Internal Temperature Rise	< 8°C (14.4°F) above ambient	The thermocouple input terminals are shorted and the temperature of the reference junction is displayed.	4-25

c. Connect a voltage divider to a dc voltage calibrator as in Figure 4-2. (See Table 4-1 for specifications.)

d. Connect the voltage-divider output to the thermometer input terminals. Match polarity.

e. Connect a variable line-power transformer to line power and adjust the output to the nominal line voltage at which the thermometer is designed to operate; 100, 115, or 230V ac.

f. Connect a power cord between the transformer output and the thermometer ac line connector.

g. Set the thermometer front-panel controls as follows:

1. POWER switch to ON.
2. TEMP switch to °F or °C.
3. TYPE SELECT switch to J.

h. Set the calibrator to zero volts output, 10 volt range, and turn it on.

4-19. Overload and Open Input

4-20. The following procedure tests the thermometer overload and open-circuit detectors:

a. Set the calibrator output to 10V dc. The thermometer display should begin to flash. While the display is lit, it should read the high end of the temperature range of the selected thermocouple type. (J was initially selected in Set-up Procedures

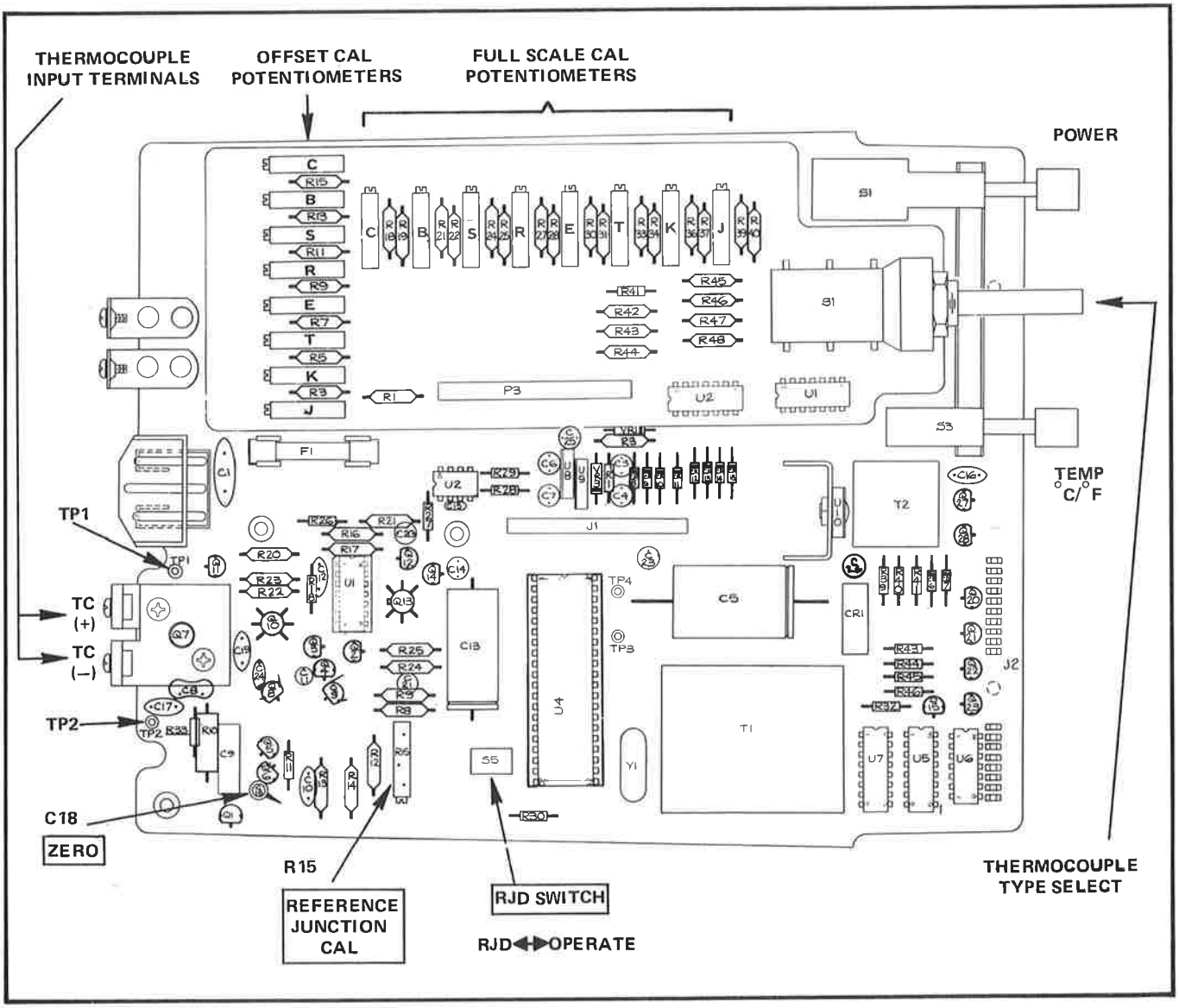


Figure 4-1. TEST POINT AND ADJUSTMENT LOCATIONS

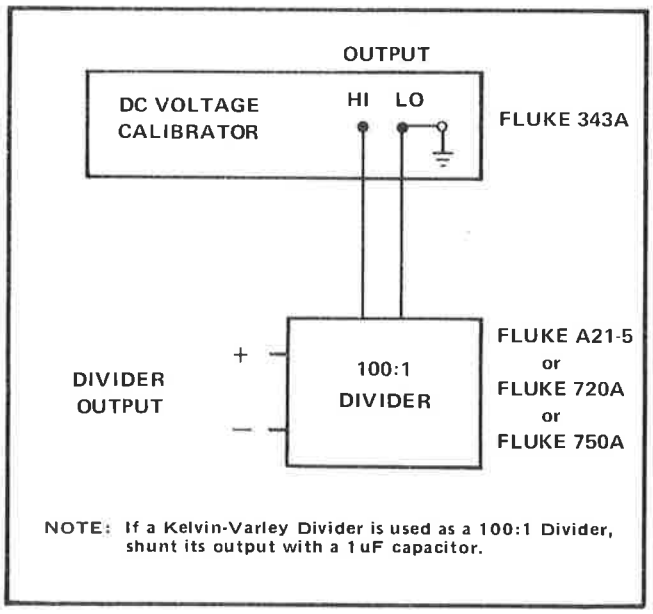


Figure 4-2. VOLTAGE DIVIDER–CALIBRATOR CONNECTION

above.) Repeat the test for the remaining settings of the TYPE-SELECT switch.

J	=	1432° F	or	778° C
K	=	2472° F	or	1356° C
T	=	752° F	or	400° C
E	=	1832° F	or	1000° C
R	=	3232° F	or	1778° C
S	=	3232° F	or	1778° C
B	=	3352° F	or	1844° C
C	=	3999° F	or	2328° C

b. Set the calibrator output to OV dc.

c. Remove the input connections at the thermometer thermocouple input terminal. Beginning with J, sequentially set the TYPE-SELECT switch to each setting. The display should begin to flash and read the low end of the temperature range of each selected thermocouple type except B which will display 32° F or 0° C. (Note: The low end of the B range is +533° C or 992° F).

J	=	-328° F	or	-200° C
K	=	-328° F	or	-200° C
T	=	-328° F	or	-200° C
E	=	-328° F	or	-200° C
R	=	32° F	or	0° C
S	=	32° F	or	0° C
B	=	32° F	or	0° C
C	=	32° F	or	0° C

d. This completes the Overload and Open-Input test.

4-21. Line Voltage Regulation

4-22. Line voltage regulation is tested in conjunction with the accuracy test given in the following paragraphs. As the accuracy test is executed, vary the line voltage ± 10% with the variable line-power transformer to ensure the proper operation within the line-voltage limits.

4-23. Accuracy Test

4-24. The following procedure tests the accuracy of the thermometer:

a. Connect the voltage-divider output leads to the thermocouple input terminals. Match polarity.

b. Set the TYPE-SELECT switch to the J-type thermocouple setting. (Double check that the RJD switch is in the RJD position.)

c. Refer to Table 4-3 and select the group of values that correspond to the J-type thermocouple.

d. Set the calibrator to obtain the output voltage listed for the J-type thermocouple, and check the thermometer display against the display limits; 90-day or 1-year. Vary the ac voltage over the specified ± 10% operating range. Check that the thermometer is still reading within accuracy specifications while varying the ac voltage. Repeat for each of the remaining TYPE-SELECT switch settings, except B.

e. After verifying accuracy for all except B, set the TYPE-SELECT switch to B and the RJD switch to OPERATE. Repeat d. above to verify accuracy of the B-type setting.

f. Remove the voltage divider from the thermometer input.

g. Install the thermometer in its case.

h. Connect a J-type thermocouple to the thermocouple input terminals. Match polarity. (J thermocouples have a red wire for the negative lead.)

i. Place the thermocouple in a room-temperature lag bath. (See Figure 4-3 for an illustration of lag-bath construction. Two holes should be drilled in the thermos lid to provide a snug fit for the mercury thermometer and thermocouple probe.)

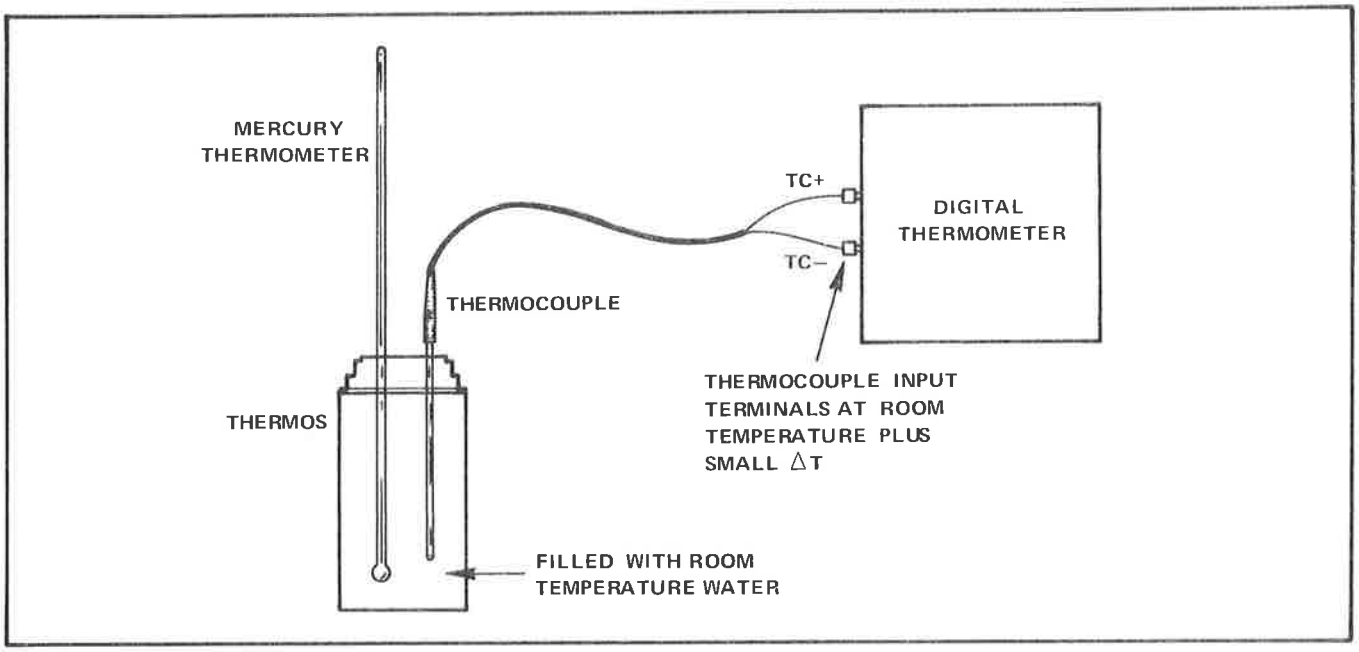


Figure 4-3. ROOM TEMPERATURE LAG BATH

Table 4-3. TEMPERATURE ACCURACY

TYPE	DIVIDER OUTPUT (mV dc)	°F DISPLAY LIMITS 90 DAY	°F DISPLAY LIMITS 1 YEAR	DIVIDER OUTPUT (mV dc)	°C DISPLAY LIMITS 90 DAY	°C DISPLAY LIMITS 1 YEAR
J	42.640	1390.5 to 1393.5	1390 to 1394	42.640	754.6 to 756.6	754.1 to 757.1
	2.288	110.5 to 113.5	110 to 114	2.288	43.4 to 45.4	42.9 to 45.9
	–1.643	–30 to –26	–30.5 to –25.5	–2.175	–45.9 to –42.9	–45.9 to –42.9
	–7.634	–310 to –306	–310.5 to –305.5	–7.344	–179.3 to –176.3	–179.3 to –176.3
K	52.789	2389.5 to 2394.5	2389 to 2395	49.638	1220.7 to 1223.7	1220.2 to 1224.2
	2.709	149.5 to 154.5	149 to 155	6.363	154.1 to 157.1	153.6 to 157.6
	–1.691	–50.5 to –45.5	–51 to –45	–1.691	–45.9 to –42.9	–46.4 to –42.4
	–5.713	–310.5 to –305.5	–311 to –305	–5.510	–179.3 to –176.3	–179.8 to –175.8
T	20.188	730.5 to 733.5	730 to 734	19.497	376.8 to 378.8	376.8 to 378.8
	0.879	70.5 to 73.5	70 to 74	0.8789	21.2 to 23.2	21.2 to 23.2
	–1.240	–30 to –26	–31.5 to –24.5	–2.009	–57.1 to –54.1	–57.6 to –53.6
	–5.421	–310 to –306	–311.5 to –304.5	–5.221	–179.3 to –176.3	–179.8 to –175.8
E	74.694	1790 to 1794	1789.5 to 1794.5	74.694	976.8 to 978.8	976.3 to 979.3
	2.694	110 to 114	109.5 to 114.5	2.694	43.4 to 45.4	42.9 to 45.9
	–1.897	–30 to –26	–31.5 to –24.5	–3.080	–57.1 to –54.1	–57.6 to –53.6
	–8.529	–310 to –306	–311.5 to –304.5	–8.209	–179.3 to –176.3	–179.8 to –175.8
R	20.951	3188 to 3196	3187 to 3197	20.951	1753.1 to 1757.1	1752.6 to 1758.6
	0.259	108 to 116	107 to 117	0.259	41.9 to 46.9	41.4 to 47.4
S	18.321	3148.5 to 3155.5	3147.5 to 3156.5	17.295	1642.4 to 1646.4	1641.4 to 1647.4
	0.262	109.5 to 114.5	107.5 to 116.5	0.262	42.2 to 46.4	41.4 to 47.4
B	13.585	3268.5 to 3276.5	3267.5 to 3276.5	13.585	1798 to 1802	1797.5 to 1802.5
	1.535	1028.5 to 1035.5	1027.5 to 1036.5	1.661	575.8 to 579.8	575.3 to 580.3
C	35.875	3977 to 3987	3977 to 3988	35.875	2191 to 2197	2191 to 2197
	1.276	187 to 197	187 to 198	.614	41 to 47	41 to 47

j. Refer to Table 4-4. Determine if the thermometer display is within the specified range of the lag-bath temperature reading.

NOTE

Allow sufficient time for the mercury thermometer to come to a stable lag-bath temperature reading.

Table 4-4. REFERENCE-JUNCTION ACCURACY LIMITS

TYPE THERMOCOUPLE	°F	°C
J	±1.5°	±1.5°
K	±2.0°	±1.5°
T	±1.5°	±1.5°
E	±1.5°	±1.5°
R	±2.5°	±2.0°
S	±2.5°	±2.0°
C	±4.5°	±3.0°
The thermometer should read within the above limits for either the 90-day or 1-year check.		

k. Using the corresponding thermocouple type, repeat i. and j. above for each of the remaining TYPE-SELECT switch settings except B. (B-type thermocouples have no output at room temperatures. See the section on Calibration Techniques.)

l. This completes the accuracy test portion of the Performance Test.

4-25. Internal Temperature Rise

4-26. The following procedure measures the thermometer's internal temperature as sensed by the reference junction:

a. Set the TYPE-SELECT switch to any setting except B.

b. Connect a copper wire between the thermocouple input terminals (in place of the thermocouple leads used in the preceding test).

NOTE

This procedure assumes that the thermometer has been energized for at least 30 minutes.

c. Monitor the ambient temperature (room temperature) using a mercury thermometer near the back of the digital thermometer.

d. The digital thermometer will display the temperature of the internal reference junction. This temperature should not exceed the ambient temperature by more than 8° C (14.4° F).

e. Remove the short from the thermocouple input terminals.

f. This completes the test for internal temperature rise.

4-27. CALIBRATION

4-28. The thermometer should be calibrated every year or every 90 days, depending on the desired accuracy. Calibration should be performed also after the thermometer has been repaired.

4-29. Calibration of either the °F or °C scale, ensures the accuracy of both scales. Either scale can be verified after calibration by executing the accuracy portion of the Performance Test.

4-30. Interpolation of calibration setting for the °F scale is not necessary to obtain the specified performance accuracy. However, the °C scale requires interpolation of the calibration setting in order to obtain the specified performance. The following examples illustrate the difference.

4-31. °F example: For a K-type thermocouple, a voltage divider output of 52.789 mV is applied to the thermometer input. (See Table 4-5.) It is necessary only to set the calibration potentiometer to any setting that results in a digital display of 2392° F.

4-32. °C example: Calibration in °C is slightly more involved. For a K-type thermocouple, Table 4-5 shows that 49.638 mV are to be applied to the thermocouple input terminals. In order to calibrate to a required ±0.25°C of the specified 1222.2° C, first adjust the potentiometer for a display flicker from 1221 to 1222. This locates the 1221.5° C position of the potentiometer. (The thermometer internally "rounds up" .5, .6, .7, .8, and .9 values, and drops .1, .2, .3 and .4). Next, count the number of turns, X, of the potentiometer to reach a display flicker from 1222 to 1223. This locates the 1222.5° C position of the potentiometer. Turn the potentiometer back .3X turns to locate the 1222.2° C position of the pot.

4-33. Observe all notes and precautions to ensure accuracy of calibration and to avoid damage to the digital thermometer. Observe also that Reference-Junction Adjustment (Paragraph 4-39) is not required for routine or periodic calibration, but that Full-Scale Calibration and Offset Adjustment is required for each setting of the TYPE-SELECT switch, with B type having a separate Offset Adjustment sequence of its own.

4-34. Calibration Procedure

4-35. SET-UP FOR CALIBRATION

a. Complete the equipment connections shown in Figure 4-2, by doing the following:

1. Connect the 100:1 divider specified in Table 4-2.
2. Apply power to the calibrator and turn it on. Allow sufficient warm-up time to assure calibration-output-voltage accuracy.

b. Remove the thermometer from its case. See paragraph 4-7.

c. Locate the RJD switch on the main pcb. Set it to the RJD position. (This defeats the reference-junction circuitry.)

d. Connect a short length of copper wire between the thermocouple input terminals.

e. Connect the digital thermometer and calibrator to the appropriate line voltage(s).

f. Set the thermometer front panel controls as follows:

1. POWER switch to ON.
2. TEMP switch to °F or °C.
3. TYPE SELECT switch to K.

4-36. ZERO ADJUSTMENT

a. Adjust C18 to obtain a steady or flashing 0 or -0 for the Celsius scale or a steady 32 for the Fahrenheit scale. This provides zero adjustment for all thermocouple types except B.

b. To provide zero adjustment for type B:

1. Set the TYPE-SELECT switch to B.
2. Set the RJD switch to OPERATE.
3. Adjust the B OFFSET CAL POTENTIOMETER, R14 (See Figures 4-1 and 8-3), to obtain a flashing 0 or -0 for the Celsius scale or to obtain a steady 32 for the Fahrenheit scale.

4-37. FULL SCALE ADJUSTMENT

a. Set the RJD switch to RJD.

b. Set the TYPE-SELECT switch to J.

c. Remove the short and connect the 100:1 divider output to the thermocouple input terminals. Match polarity.

d. Refer to Table 4-5 and set the calibrator output to obtain the voltage divider output specified for the degree scale being used and for the thermocouple type selected by the TYPE-SELECT switch.

e. Adjust the FULL-SCALE POTENTIOMETER, for the thermocouple type selected (Figures 4-1 & 8-3), to obtain the temperature display specified in Table 4-5.

Table 4-5. FULL SCALE CALIBRATION

PROBE TYPE	°F		°C	
	DIVIDER OUTPUT (mV dc)	DISPLAY READING	DIVIDER OUTPUT (mV dc)	DISPLAY READING
J	+42.640	1392°F	+42.640	755.6°C
K	+52.789	2392°F	+49.638	1222.2°C
T	+20.188	732°F	+19.497	377.8°C
E	+74.694	1792°F	+74.694	977.8°C
R	+20.951	3192°F	+20.951	1755.6°C
S	+18.321	3152°F	+17.295	1644.4°C
B	+13.585	3272°F	+13.585	1800.0°C
C	+35.875	3982°F	+35.875	2194.4°C

f. Repeat d. and e. above for each thermocouple TYPE-SELECT switch setting, except B.

g. For the B-type thermocouple setting:

1. Set the RJD switch to OPERATE.
2. Repeat d. and e. above for the B-type thermocouple,

4-38. OFFSET ADJUSTMENT:

a. Set the RJD switch to the operate position.

b. Remove the divider leads from the thermocouple input terminals.

c. Short the thermocouple input terminals with a small piece of copper wire.

d. Remove the 100:1 divider from the calibrator output.

e. Set the Calibrator to the 10V dc range.

f. Adjust the calibrator output to .5785V dc.

CAUTION

Be sure the voltage output of the calibrator is .5785V dc before proceeding to the next step. Improper voltage could damage the digital thermometer. Do not use the divider to obtain .5785V dc because the output impedance will create an error.

g. Connect the positive lead from the calibrator to TC+, the positive thermocouple input terminal.

h. Connect the negative lead from the calibrator to Test Point 2. (TP2(–) in Figure 4-1).

i. Sequentially set the TYPE-SELECT switch to each setting except B, and adjust the corresponding OFFSET CAL POTENTIOMETER (Figures 4-1 & 8-3) to obtain a display of 77° F or 25° C ± ¼° C. (See Paragraph 4-30 on interpolation.)

j. Remove the calibrator output from the thermocouple plus input (TC+) and TP2(–).

k. Remove the short at the thermocouple input terminals.

l. If the thermometer is being calibrated on a routine calibration cycle, this completes calibration. Reassemble the thermometer.

m. If the thermometer is being recalibrated because of repair or if reference-junction adjustment is desired, proceed with paragraph 4-39.

4-39. REFERENCE-JUNCTION ADJUSTMENT

a. Set the TYPE-SELECT switch to any position except B.

b. Connect the appropriate probe to the input terminals; Match polarity. J, K, T, and E thermocouples have a red wire for the negative lead. Refer to the manufacturer for R, S, and C color coding.

c. Place the thermocouple in a room-temperature lag bath. (See Figure 4-3 for an illustration of lag-bath construction.)

d. Use an accurate mercury thermometer to monitor the temperature of the lag-bath. (See Table 4-1.)

e. Adjust the REFERENCE-JUNCTION CAL potentiometer, R15, to obtain a display that agrees with the lag-bath temperature.

f. Remove the thermocouple and reassemble the digital thermometer.

4-40. REFERENCE-JUNCTION BIAS-RESISTOR SELECTION

4-41. If the reference-junction transistor Q7 is replaced, then the reference-junction bias resistor R14 must also be replaced. This is a selected resitor which must be matched to Q7. To select the resistor:

a. Complete the calibration paragraphs 4-35 through 4-38.

b. Connect a compatible thermocouple probe to the input terminals. Match polarity. J, K, T and E thermocouples have a red wire for the negative lead. Refer to the manufacturer for R, S and C color coding.

c. Center the reference-junction pot R15.

d. Connect a decade resistance box that has ranges including 1K, 10K, and 100K, in place of the reference-junction bias resistor R14. (See Table 4-1.)

e. Place the thermocouple in a room-temperature lag bath. (See Table 4-3 for an illustration of lag-bath construction.)

f. Use an accurate mercury thermometer to monitor the temperature of the lag bath. (See Table 4-1.)

g. Adjust the decade resistance box for the value from Table 4-6 that causes the thermometer to read closest to lag-bath temperature. This will be the value of the reference-junction bias resistor R14.

h. Disconnect the decade box and install the selected R14.

i. Adjust the reference junction potentiometer so that the thermometer reading matches the lag-bath temperature.

j. Remove the thermocouple and reassemble the digital thermometer.

k. This completes the selection of R14. This also completes the calibration of the reference junction.

Table 4-6. BIAS RESISTOR VALUES

VALUE	JOHN FLUKE PART NUMBER	VALUE	JOHN FLUKE PART NUMBER
49.9K	268821	90.9K	223537
52.3K	237248	100K	248807
54.9K	271353	110K	234708
57.6K	289116	124K	288407
60.4K	291419	140K	289439
63.4K	235382	162K	375998
68.1K	236828	191K	375923
73.2K	237222	237K	288373
78.7K	289058	309K	235283
84.5K	229492	562K	235358

4-42. CALIBRATION TECHNIQUES

4-43. Calibration of the reference junction (R15) can be performed using any type of thermocouple except B-type. Once the reference junction has been calibrated for one type of thermocouple, it will be in calibration for use with any other thermocouple type. (Type B thermocouples do not use the reference junction due to their low output levels at room temperature.)Although any thermocouple can be used to calibrate the reference junction, the K-type thermocouple is recommended because it has the highest sensitivity of the base-metal thermocouples offered.

4-44. Thermocouple Accuracy Relating to the Reference-Junction Calibration Technique

4-45. The thermocouples specified in the list of calibration equipment meet specifications of ANSI Standard C96.1. The specifications for these probes can be as much as 4°F absolute error at or near room temperature. The first conclusion is that those probes could produce a calibration error of ± 4° F when used for calibrating the reference junction. This is an erroneous conclusion. Figure 4-3 illustrates the set-up for calibration. Figure 4-4A illustrates the reference-junction compensation circuitry and Figure 4-4B illustrates the equivalent thermocouple circuit formed by the connection of the thermocouple to the input of the

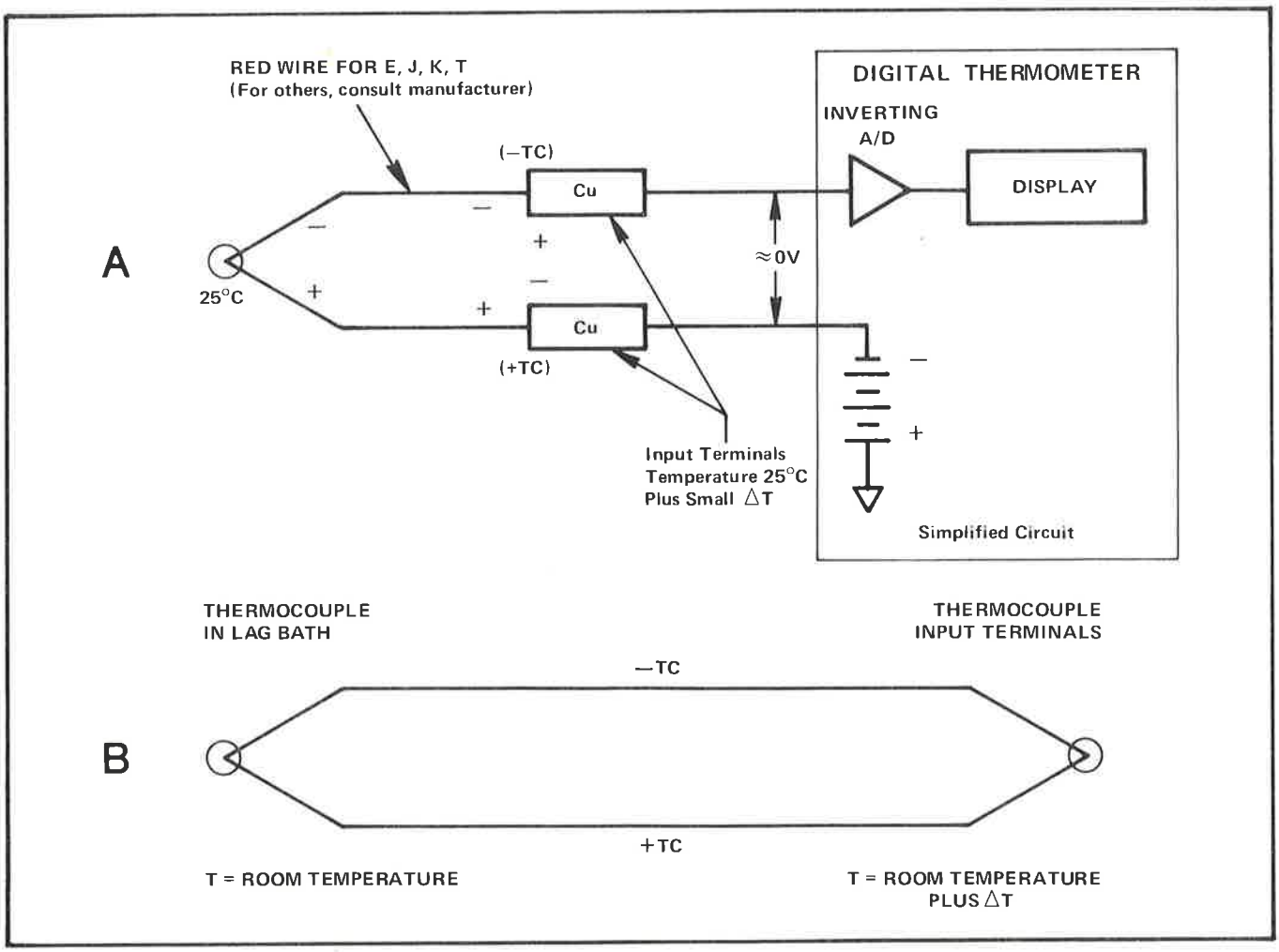


Figure 4-4. REFERENCE-JUNCTION COMPENSATION CIRCUITRY

instrument. Note that in Figure 4-4B, the two thermocouple junctions formed at the input of the instrument (plus thermocouple wire (+TC) to the plus input terminal and the minus thermocouple wire (–TC) to the minus input terminal) can be represented as a single junction of +TC to –TC whose temperature is that of the input terminals of the instrument. The reference-junction circuitry senses the terminal temperature and generates a voltage that is equal to the voltage generated by the equivalent thermocouple formed at the input terminals referenced to ice point (See Figure 4-4A). For example, suppose the input terminals of the instrument and the attached probe are at the same temperature of 25° C. Since the thermocouple output voltage is proportional to the temperature between the two junctions, the output is zero volts. The reference-junction circuitry supplies a compensating voltage to the instrument such that the instrument will read 25° C. When calibrating the reference junction using the lag-bath technique, the reference is adjusted so that the instrument reads the lag-bath temperature. In using the lag-bath technique, there is only a small temperature difference, ΔT, between the thermocouple junction in the probe and the equivalent thermocouple junction formed at the input terminals of the instrument. The voltage output across the thermocouple circuit is proportional to the temperature difference, ΔT, between the two junctions. Hence, since ΔT is small, there is a small input voltage applied to the input of the instrument. This small input voltage will represent ΔT accurately to within less than .1° F. Therefore, when the reference junction is calibrated so that the instrument reads lag-bath temperature, the error introduced by the thermocouple will be less than .1° F.

4-46. Over-all Accuracy

4-47. The instrument will read very accurately around room temperature (See paragraph 4-44) but as the measured temperature increases or decreases from room temperature, the amount of thermocouple output deviation from NBS Standard 125, becomes the limiting factor in the accuracy of the instrument. If the thermocouple is in error by +4° F, at 900° F the display will be +4° F higher than if the thermocouple conformed perfectly to NBS Standard 125. Error specifications for the instrument do not include thermocouple probe inaccuracies. Those errors must be added to the instrument error in order to obtain an over-all accuracy figure.

4-48. TROUBLE SHOOTING

4-49. A troubleshooting guide for the thermometer is given in Table 4-7. The guide is a simplified decision table and is recommended for use in isolating a problem to a functional circuit group. Details necessary to troubleshoot a fault in a functional circuit group can be derived from Section 3 Theory of Operation and Section 8 Schematic Diagrams.

Table 4-7. TROUBLESHOOTING GUIDE

STEP	INSTRUCTION	IF YES GO TO	IF NO GO TO	GO TO
1	Energize the unit and connect a short across the thermocouple input terminals.			2
2	Does the display light?	16	3	
3	Is the power fuse blown?	4	5	
4	Replace fuse.			2
5	Are all power supply voltages present; +5, +6.8, +15 and −12V dc?	7	6	
6	Repair power supply.			2
7	Are Strobe Out pulses present at pins 9, 10, 11 and 12 of U4. (Use logic common as reference.)?	10	8	
8	Is crystal operating?	10	9	
9	Replace crystal.			2
10	Are display drivers functioning?	13	11	
11	Is output data present at pins 4, 5, 6 and 7 of U4?	12	13	
12	Replace display drivers as necessary.			2
13	Are $\overline{\Delta 2}$, AZ, INT, DE+ or DE−, and CM present at U4?	14	15	
14	Display PCB defective. Repair as necessary.			2
15	U4 is defective. Replace.			2
16	Does display read approximate ambient temperature?	21	17	
17	Refer to Section 3 of this manual and use a scope to check for the presence of the waveforms shown in Figure 3-2.			18
18	Are all waveforms correct?	20	19	
19	Perform the necessary repairs to the analog circuit.			17
20	Calibrate the thermometer.			21
21	End. Thermometer is functional.			

PERFORMANCE TEST CHECKLIST

Fluke Model 2168A Digital Thermometer

Serial Number_____
Tested By:_____
Date:_____

°F VERIFICATION TABLE (TEMPERATURE ACCURACY)

PROBE TYPE	NOMINAL TEMPERATURE °F	90 DAY			1 YEAR		
		MIN.	ACTUAL	MAX.	MIN.	ACTUAL	MAX.
J	1392	1390.5		1393.5	1390		1394
	112	110.5		113.5	110		114
	−28	−30		−26	−30.5		−25.5
	−308	−310		−306	−310.5		−305.5
K	2392	2389.5		2394.5	2389		2395
	152	149.5		154.4	149		155
	−48	−50.5		−45.5	−51		−45
	−308	−310.5		−305.5	−311		−305
T	732	730.5		733.5	730		734
	72	70.5		73.5	70		74
	−28	−30		−26	−31.5		−24.5
	−308	−310		−306	−311.5		−304.5
E	1792	1790		1794	1789.5		1794.5
	112	110		114	109.5		114.5
	−28	−30		−26	−31.5		−24.5
	−308	−310		−306	−311.5		−304.5
R	3192	3188		3196	3187		3197
	112	108		116	107		117
S	3152	3148.5		3155.5	3147.5		3156.5
	112	109.5		114.5	107.5		116.5
B	3272	3268.5		3275.5	3267.5		3276.5
	1032	1028.5		1035.5	1027.5		1036.5
C	3982	3977		3987	3977		3988
	192	187		197	187		198

Line Voltage Regulation _____ Passed ( ) Failed ( )

Accuracy Test _____ See Verification Tables

°F VERIFICATION TABLE (REFERENCE JUNCTION ACCURACY)

PROBE TYPE	90-Day or 1-Year	
	Deviation Error From Room-Temperature Lag Bath	
	Maximum	Actual
J	±1.5°	
K	±2.0°	
T	±1.5°	
E	±1.5°	
R	±2.5°	
S	±2.5°	
C	±4.5°	

PERFORMANCE TEST CHECKLIST, Cont.

°C VERIFICATION TABLE (REFERENCE-JUNCTION ACCURACY)

PROBE TYPE	NOMINAL TEMPERATURE °C	90 DAY			1 YEAR		
		MIN.	ACTUAL	MAX.	MIN.	ACTUAL	MAX.
J	755.4	754.6	_____	756.6	754.1	_____	757.1
	44.4	43.4	_____	45.4	42.9	_____	45.9
	−45.9	−45.9	_____	−42.2	−45.9	_____	−42.9
	−178.8	−179.3	_____	−176.3	−179.3	_____	−176.3
K	1222.2	1220.7	_____	1223.7	1220.2	_____	1224.2
	155.6	154.1	_____	157.1	153.6	_____	157.6
	−44.4	−45.9	_____	−42.9	−46.4	_____	−42.4
	−177.8	−179.3	_____	−176.3	−179.8	_____	−175.8
T	377.8	376.8	_____	378.8	376.8	_____	378.8
	22.2	21.2	_____	23.2	21.2	_____	23.2
	−55.6	−57.1	_____	−54.1	−57.6	_____	−53.6
	−177.8	−179.3	_____	−176.3	−179.8	_____	−175.8
E	977.8	976.8	_____	978.8	976.3	_____	979.3
	44.4	43.4	_____	45.4	42.9	_____	45.9
	−55.6	−57.1	_____	−54.1	−57.6	_____	−53.6
	−177.8	−179.3	_____	−176.3	−179.8	_____	−175.8
R	1755.6	1753.1	_____	1757.1	1752.6	_____	1758.6
	44.4	41.9	_____	46.9	41.4	_____	47.4
S	1644.4	1642.4	_____	1646.4	1641.4	_____	1647.4
	44.4	42.2	_____	46.4	41.4	_____	47.4
B	1800	1798	_____	1802	1797.5	_____	1802.5
	577.8	575.8	_____	579.8	575.3	_____	580.3
C	2194.4	2190.9	_____	2197.9	2190.4	_____	2198.4
	44.4	40.8	_____	47.9	40.4	_____	48.4

Overload

Overrange _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ Passed ( ) Failed ( )

Open Circuit _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ Passed ( ) Failed ( )

Internal Temperature Rise _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ <8°C (14.4° F) above ambient

°C VERIFICATION TABLE (REFERENCE-JUNCTION ACCURACY

PROBE TYPE	90-Day or 1-Year	
	Deviation Error From Room-Temperature Lag Bath	
	Maximum	Actual
J	±1.5°	
K	±1.5°	
T	±1.5°	
E	±1.5°	
R	±2.0°	
S	±2.0°	
C	±3.0°	

Section 5
Lists of Replaceable Parts

5-1. INTRODUCTION

5-2. This section contains an illustrated parts breakdown of the instrument. Components are listed alpha-numerically by assembly. Electrical components are listed by reference designation and mechanical components are listed by item number. Each listed part is shown in an accompanying illustration.

5-3. Parts lists include the following information:

a. Reference Designation or Item Number.

b. Description of each part.

c. Fluke Stock Number.

d. Federal Supply Code for Manufacturers. (See Appendix A for Code-to-Name list.)

e. Manufacturer's part Number or Type.

f. Total Quantity per assembly or component.

g. Recommended Quantity: This entry indicates the recommended number of spare parts necessary to support one to five instruments for a period of two years. This list presumes an availability of common electronic parts at the maintenance site. For maintenance for one year or more at an isolated site, it is recommended that at least one of each assembly in the instrument be stocked. In the case of optional subassemblies, plug-ins, etc. that are not always part of the instrument, or are deviations from the basic instrument mode, the REC QTY column lists the recommended quantity of the item in that particular assembly.

h. Use Code is provided to identify certain parts that have been added, deleted or modified during production of the instrument. Each part for which a use code has been assigned may be identified with a particular instrument serial number by consulting the Use Code Effectivity, paragraph 5-7.

5-4. HOW TO OBTAIN PARTS

5-5. Components may be ordered directly from the manufacturer by using the manufacturer's part number, or from the John Fluke Mfg. Co., Inc. factory or authorized representative by using the FLUKE STOCK NUMBER. In the event the part you order has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions, if necessary.

5-6. To ensure prompt and efficient handling of your order, include the following information.

a. Quantity

b. FLUKE Stock Number

c. Description

d. Reference Designation or Item Number

e. Printed Circuit Board Part Number

f. Instrument model and Serial number

5-7. USE CODE EFFECTIVITY LIST

USE CODE	SERIAL NUMBER EFFECTIVITY
A	0123 to 50000
B	50000 and on

Indicates MOS device which may be damaged by static discharge.

FINAL ASSEMBLY, 2168A

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
	DIGITAL THERMOMETER FINAL ASSEMBLY 2168A						
A1	Thermometer Assembly				1		
	100V ac (2168A-4001T-2)	438523	89536	438523			
	115V ac (2168A-4001T)	425611	89536	425611			
	230V ac (2168A-4001T)	425611	89536	425611			
A2	Display PCB Assembly (2165A-4003)	443515	89536	443515	1		
1	Adhesive, lens	436766	89536	436766	1		
2	Case, molded plastic	434431	89536	434431	1		
3	Cord, ac line				1		
	100 or 115V ac	343723	89536	343723	1		
	230V ac	343780	89536	343780	1		
4	Decal, case bottom	412259	89536	412259	1		
5	Decal, front panel	428573	89536	428573	1		
6	Decal, handle	347401	89536	347401	1		
7	Decal, switch knob	428540	89536	428540	1		
8	Feet, rubber	338632	89536	338632	2		
9	Handle, molded plastic	330092	89536	330092	1		
10	Knob, switch	438697	89536	438697	1		
11	Lens, display	419085	89536	419085	1		
12	Panel, front	417485	89536	417485	1		
13	Retainer, neoprene	352484	89536	352484	1		
14	Shield	438440	89536	438440	1		
15	Washer	340505	89536	340505	2		

A1 THERMOMETER ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
A1	**THERMOMETER ASSEMBLY**				REF		
	100V ac (2168A-4001T-2)	438523	89536	438523			
	115V ac (2168A-4001T)	425611	89536	425611			
	230V ac (2168A-4001T)	425611	89536	425611			
A1A1	Thermometer PCB Assembly (2168A-4001)	425579	89536	425579	1		
A1A2	Type Select PCB Assembly (2168A-4002)	425561	89536	425561	1		
T1	Transformer, Power				1		
	100V ac (2165A-6550)	437624	89536	437624			
	115V ac (2166A-6510)	437616	89536	437616			
	230V ac (2166A-6510)	437616	89536	437616			
U4	IC, LSI, digital P-MOS ⊗	403527	70203	C-10186	1	1	

A1A1 THERMOMETER PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR . TYPE	TOT QTY	REC QTY	USE CDE
A1A1	**THERMOMETER PCB ASSEMBLY (2168A-4001)**	425579	89536	425579	REF		
	Figure 8-1						
C1	Cap, cer, .01 uF ±20%, 3kV	266320	56289	41C301A2	1		
C3,C4, C26	Cap, Ta, 6.8 uF ±20%, 35V	363713	56289	196D685X0035 KA1	3		
C5	Cap, elect, 4700 uF −10/+100%, 15V	379370	25088	B41010-4700/16	1	1	
C6,C7, C14, C20, C21, C23, C25	Cap, Ta, 10 uF ±20%, 20V	330662	56289	196D106X0020 KA1	7		
C8	Cap, mica, 100 pF ±1%, 500V	226126	71234	DM15F100F	1		
C9	Cap, mylar, 0.47 ±10%, 100V	369124	73445	C280MAH/A47 0K	1		
C10	Cap, disc, 100 pF ±10%, 1kV	105593	56289	DD101	1		
C11	Cap, Ta, 2.2 uF ±10%, 15V	364216	56289	196D222X9015 HA1	1		
C12	Cap, cer, .025 ±20%, 100V	168435	56289	C023B101H235 M	1		
C13	Cap, polypro, 0.47 uF ±10%, 50V	363085	89536	363085	1		
C15	Cap, cer, 2700 pF ±20%, 100V	362889	72982	8121-A100-W5R-272M	1		
C16	Cap, cer, .0012 uF ±10%, 500V	106732	71590	CF122	1		
C17, C19	Cap, cer, 1000 pF ±10%, 500V	357806	56289	C106B102G102 K	2		
C18	Cap, var, 0.25 to 1.5 pF, 2kV	218206	72982	530-000	1	1	
C24	Cap, cer, 1 pF ±0.25 pF, 100V	436477	72982	8101-A100-C0G-109G	1		
CR1	Diode, bridge rectifier	392910	89536	392910	1	1	
CR2	Diode, rectifier, Si	343491	01295	1N4002	1	1	
CR6 thru CR15	Diode, Si, 150 mA, 75V	203323	07910	1N4448	10	2	

A1A1 THERMOMETER PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
F1	Fuse, slo-blo, 1/8A	166488	71400	MDL1-8	1	5	
J1	Connector, female, 18-pin	435024	00779	583773-8	1		
J2	Connector, post-pin	267500	00779	86144-2	18		
J3	Connector, post-pin	267633	00779	86144-1	12		
Q1 thru Q6,Q8, Q9,Q12, Q14	Xstr, J-FET, N-channel	343830	89536	343830	10	2	
Q7	Xstr, Si, NPN	329698	07263	2N2484	1	1	
Q10	Xstr, FET, dual N-channel	439703	89536	439703	1	1	
Q11,Q15	Xstr, Si, NPN	218396	04713	2N3904	2	1	
Q13	Xstr, FET, dual N-channel	379321	89536	379321	1	1	
Q20 thru Q23	Xstr, Si, NPN	381798	04713	MPS A-13	4	1	
Q27, Q28	Xstr, Si, NPN	272237	07263	2N4946	2	1	
R1	Res, comp, 430 ±5%, ½W	109058	01121	EB4315	1		
R3	Res, mf, 2.15k ±1%, 1/8W	293712	91637	MFF1-82151F	1		
R8	Res, mf, 2k ±0.1%, 1/8W	340174	91637	MFF1-82001B	1		
R9	Res, mf, 1k ±0.1%, 1/8W	340380	91637	MFF1-81001B	1		
R10	Res, comp, 47k ±5%, 1W	150219	01121	GB4735	1		
R11, R29	Res, comp, 1M ±5%, ¼W	182204	01121	CB1055	2		
R12	Res, mf, 26.7k ±0.1%, 1/8W	344465	91637	MFF1-82672B	1		
R13	Res, mf, 150k ±1%, 1/8W	241083	91637	MFF1-81503F	1		
R15	Res, var, 50k ±20%, ½W	330688	71450	190PC503B	1	1	
R16, R17	Res, mf, 14.7k ±1%, 1/8W	226225	91637	MFF1-81472F	2		
R18	Res, comp, 470 ±5%, 1/4W	147983	01121	CB4715	1		
R20	Res, mf, 28.7k ±1%, 1/8W	235176	91637	MFF1-82872F	1		
R21	Res, mf, 61.9k ±1%, 1/8W	237230	91637	MFF1-86192F	1		
R22	Res, mf, 19.1k ±1%, 1/8W	234963	91637	MFF1-81912F	1		

A1A1 THERMOMETER PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R23	Res, mf, 1k ±1%, 1/8W	168229	91637	MFF1-81001F	1		
R24, R25	Res, mf, 82.5k ±1%, 1/8W	246223	91637	MFF1-88252F	2		
R26	Res, comp, 680k ±5%, ¼W	188433	01121	CB6845	1		
R27	Res, comp, 100 ±5%, ¼W	147926	01121	CB1015	1		
R28, R33	Res, comp, 220k ±5%, ¼W	160937	01121	CB2245	2		
R30, R32	Res, comp, 20k ±5%, ¼W	221614	01121	CB2035	2		
R39	Res, comp, 2k ±5%, ¼W	202879	01121	CB2025	1		
R40	Res, comp, 22 ±5%, ¼W	147884	01121	CB2205	1		
R41	Res, comp, 330 ±5%, ¼W	147967	01121	CB3315	1		
R43 thru R46	Res, comp, 27k ±5%, ¼W	148148	01121	CB2735	4		
S1,S3	Switch Assembly	428508	89536	428508	1		
S5	Switch, slide, dpdt	423129	95146	SLS-220-1	1	1	
T2	Xfmr, Inverter	436105	89536	436105	1		
U1	IC, dual opnl ampl	404087	49956	RC4739DP	1	1	
U2	IC, opnl ampl	352195	49956	RC311DN	1	1	
U5	IC, TTL, bcd-to-7 segment decoder/driver	340109	01295	SN7447N	1	1	
U6	IC, res network, 60Ω	344069	89536	344069	1	1	
U7	IC, C-MOS, Hex Buffer/Inverter ⊗	381830	02735	CD4050AE	1	1	
U8	IC, linear voltage regulator, +15V	413187	12040	LM340T-18	1	1	
U9	IC, linear voltage regulator, −12V	381665	04713	MC7912CP	1	1	
U10	IC, linear voltage regulator, +8V	407627	04713	MC7808CP	1	1	
VR1	Diode, zener, 10V	429019	04713	1N4582	1	1	
VR3	Diode, zener, 6.8V	260697	07910	1N754A	1	1	
Y1	Crystal, 400 kHz	403352	89536	403352	1		
1	Button, gray	419689	89536	419689	1		
2	Button, green	419747	89536	419747	1		

A1A1 THERMOMETER PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
3	Connector, ac line						
	Contact, ground	338640	89536	338640	1		
	Contact, voltage	338657	89536	338657	2		
	Insulator, paper	344184	89536	344184	1		
	Insulator, plastic	338624	89536	338624	1		
4	Heat Sink	352765	98978	PA1-1CB	1		
5	Isothermal Block						
	Insulator	415695	89536	415695	1		
	Plate, terminal, neg	415687	89536	415687	1		
	Plate, terminal, pos	415679	89536	415679	1		
6	Socket, IC, 40-pin	418988	91506	403-AG37D	1		

A1A2 TYPE SELECT PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
A1A2	**TYPE SELECT PCB ASSEMBLY (2168A-4002)** **Figure 8-2**	425561	89536	425561	REF		
P3	Connector, receptacle	267476	00779	85861-2	12		
R1,R3, R5,R7, R9, R11, R13, R15	Res, mf, 261k ±1%, 1/8W	257535	91637	MFF1-82613F	8		
R2, R4 R6, R8, R14, R17, R20, R23, R26, R29, R32, R35, R38	Res, var, 25k ±20%, ½W	285213	75378	190PC253B	13	5	
R18	Res, mf, 590 ±1%, 1/8W	446625	91637	MFF1-85900F	1		
R19, R22, R25, R28, R31, R34, R37, R40	Res, mf, 187k ±1%, 1/8W	257469	91637	MFF1-81873F	8		
R21	Res, mf, 143 ±1%, 1/8W	423699	91637	MFF1-81430F	1		
R24, R27	Res, mf, 324 ±1%, 1/8W	423780	91637	MFF1-83240F	2		
R30	Res, mf, 53.6k ±1%, 1/8W	291401	91637	MFF1-85362F	1		
R33, R36	Res, mf, 3.74k ±1%, 1/8W	260547	91637	MFF1-83741F	2		
R39	Res, mf, 10.7k ±1%, 1/8W	423681	91637	MFF1-81072F	1		

A1A2 TYPE SELECT PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R41	Res, comp, 3.3 ±5%, ¼W	182279	01121	CB3325	1		
R42	Res, mf, 69.5 ±0.1%, 1/8W	423756	91637	MFF1-86952B	1		
R43	Res, mf, 483.7 ±0.1%, 1/8W	423731	91637	MFF1-8483R7B	1		
R44	Res, mf, 619 ±0.1%, 1/8W	423715	91637	MFF1-86190B	1		
R45	Res, mf, 164.3 ±0.1%, 1/8W	424564	91637	MFF1-8164R3	1		
R46	Res, mf, 70.0 ±0.1%, 1/8W	423764	91637	MFF1-8A70R0B	1		
R47	Res, mf, 732 ±0.1%, 1/8W	423749	91637	MFF1-87320B	1		
R48	Res, mf, 481.4 ±0.1%, 1/8W	423723	91637	MFF1-8481R4B	1		
S1	Switch, rotary, 3-pole, 8-position	428599	81073	71BY231033-8N	1	1	
U1	IC, TTL, 8-bit priority encoder	412973	02735	CD4532BE	1	1	
U2	Res, network, 100k	404624	89536	404624	1	1	
	PC, Mount	418897	89536	418897	1		

A2 DISPLAY PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
A2	**DISPLAY PCB ASSEMBLY (2165A-4003)** **Figure 8-3**	443515	89536	443515	REF		
DS1, DS2	LED, dual 7-segment character display	419051	29083	MAN 6610	2	1	A
DS3	LED, 7-segment character display	407874	29083	MAN 4610	1	1	A
DS1 thru DS5	LED, 7-segment numeric display	418012	28480	5082-7651	5	1	B
P4	Connector, female, 16-pin	375329	00779	85863-3	1		
R1	Res, comp, 91 ±5%, ¼W	221887	01121	CB9105	1		

Section 6

Option & Accessory Information

6-1. INTRODUCTION

6-2. This section of the manual contains information concerning the Options and Accessories available for use with the Model 2168A Digital Thermometer. The first portion of this section provides a brief description of each option and accessory. The depth of detail is intended to give the prospective user an adequate first aquaintance with the features and capabilities of each. Detailed information concerning specifications, operating instructions, maintenance, list of replacable parts and schematics is supplied separately with some options and accessories, and is designed to comprise the second portion of this section. Unique page and paragraph numbering is assigned to each of the add-on descriptions to allow separation into easily identifiable subsections. The material is prepunched (T-punched) to permit insertion without disassembling the manual. Table 6-1 lists the available options and accessories and defines the manner in which each is documented.

Table 6-1. OPTIONS AND ACCESSORIES

MODEL OR OPTION NO.	DESCRIPTION	DOCUMENTATION SUPPLIED	
		WITH UNIT	HERE IN
C80	Carrying Case		●
C86	Carrying Case		●
P20J	J-Type TC Probe		●
P20K	K-Type TC Probe		●
P20T	T-Type TC Probe		●
M00-100-714	Front Panel Dust Cover		●
M00-200-611	Rack Mtg. Kit, Offset	○	
M00-200-612	Rack Mtg. Kit, Center	○	
M00-200-613	Rack Mtf. Side-by-Side	○	
2160A-7022	Interface Cable		●
–02	Digital Output Unit	○	
–04	Analog Output Unit	○	

○ = T-punched for insertion in Section 6 of this manual

● = Not T-punched

6-3. CARRYING CASE (C80)

6-4. The Model C80 Carrying Case, Figure 6-1, is a soft vinyl plastic container designed for the storage and transport of the 2168A. The case provides the unit with adequate protection against normal handling and storage conditions. In addition to a shoulder strap, the C80 is equipped with a storage compartment for probes, power cord, and other compact accessories.

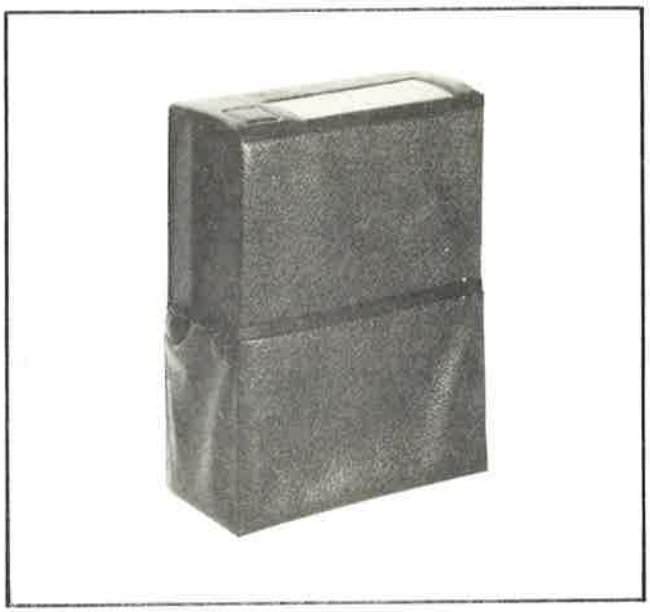


Figure 6-1. C80 Carrying Case

6-5. CARRYING CASE (C86)

6-6. The Model C86 Carrying Case, Figure 6-2, is a molded polyethylene container, with handle, designed for use in transporting the 2168A. This rugged case provides the unit with maximum protection against rough handling and adverse weather conditions. A separate storage compartment is provided for probes, power cord, and other compact accessories.

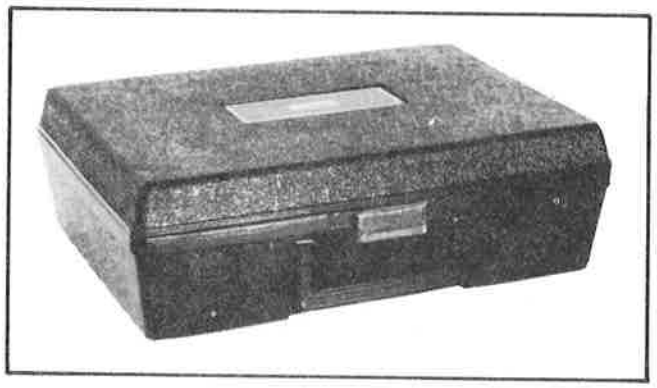


Figure 6-2. C86 CARRYING CASE

6-7. THERMOCOUPLE PROBES

6-8. Three types of thermocouple probe assemblies (J, K and T) are available from Fluke for use with the 2168A. See Table 6-1. Each thermocouple is enclosed in a 6-inch x 1/8 inch iconel sheath, and includes a heavy duty transition splice and spring. See Figure 6-3. The thermocouple junction is grounded to the sheath, and 36-inch trimmed leads are included on all units. Refer to the Tables under Specifications in Section 1 of this manual for the temperature range recommended for each thermocouple type.

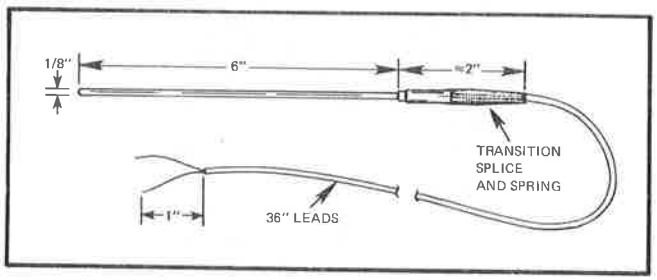


Figure 6-3. P20 SERIES THERMOCOUPLE PROBES

6-9. FRONT PANEL DUST COVER (M00-100-714)

6-10. The front panel dust cover is a molded plastic snap-on accessory which fits over the front panel of the 2168A. The dust cover provides protection for the front panel controls, and is useful when storing or transporting the unit.

6-11. RACK MOUNTING KITS

6-12. Three rack mounting kits are available for mounting the 2168A in a standard 19-inch equipment rack. The kits, listed in Table 6-1, provide the option of either offset mounting (left/right), center mounting or side-by-side mounting.

6-13. DIGITAL OUTPUT UNIT, OPTION –02

NOTE

The Digital Output Unit is not operational when the 2168A is powered by an external 12V dc source.

6-14. The Digital Output Unit (Option –02) is a field installable pcb that mounts on the interior of the 2168A and provides a digital output which is equivalent to the displayed measurement data. The digital output is positive-true, TTL compatible and is presented in bcd, character-parallel format. All displayed characters are represented at the output. Output data is solicited by an External Trigger input and valid data is ensured by Busy and $\overline{\text{Busy}}$ outputs.

6-15. External connections to the Digital Output Unit are made through a 34-pin cable which is supplied with the pcb.

6-16. ANALOG OUTPUT UNIT, OPTION –04

NOTE

The Analog Output Unit is not operational when the 2168A is powered by an external 12V dc source.

6-17. The Analog Output Unit is a field installable pcb assembly which provides the 2168A with a rear-panel analog output voltage proportional to the displayed measurement data. The output voltage is electrically isolated from the 2168A and covers a voltage range of –0.4 to +4V dc. Automatic polarity sensing is provided for both °C and °F measurements to ensure that the polarity of the output voltage agrees with the displayed polarity. Since the analog output terminals are isolated from the 2168A, the output voltage is referenced to the low terminal of the external recording device (voltmeter, strip-chart recorder, etc.).

6-18. External connections to the Analog Output Unit are made through a connector and cable which is supplied with the pcb.

Section 7
General Information

7-1. This section of the manual contains generalized user information as well as supplemental information to the List of Replaceable Parts contained in Section 5.

List of Abbreviations and Symbols

A or amp	ampere
ac	alternating current
af	audio frequency
a/d	analog-to-digital
assy	assembly
AWG	american wire gauge
B	bel
bcd	binary coded decimal
°C	Celsius
cap	capacitor
ccw	counterclockwise
cer	ceramic
cermet	ceramic to metal(seal)
ckt	circuit
cm	centimeter
cmrr	common mode rejection ratio
comp	composition
cont	continue
crt	cathode-ray tube
cw	clockwise
d/a	digital-to-analog
dac	digital-to-analog converter
dB	decibel
dc	direct current
dmm	digital multimeter
dvm	digital voltmeter
elect	electrolytic
ext	external
F	farad
°F	Fahrenheit
FET	Field-effect transistor
ff	flip-flop
freq	frequency
FSN	federal stock number
g	gram
G	giga (10^9)
gd	guard
Ge	germanium
GHz	gigahertz
gmv	guaranteed minimum value
gnd	ground
H	henry
hd	heavy duty
hf	high frequency
Hz	hertz
IC	integrated circuit
if	intermediate frequency
in	inch(es)
intl	internal
I/O	input/output
k	kilo (10^3)
kHz	kilohertz
kΩ	kilohm(s)
kV	kilovolt(s)
lf	low frequency
LED	light-emitting diode
LSB	least significant bit
LSD	least significant digit
M	mega (10^6)
m	milli (10^{-3})
mA	milliampere(s)
max	maximum
mf	metal film
MHz	megahertz
min	minimum
mm	millimeter
ms	millisecond
MSB	most significant bit
MSD	most significant digit
MTBF	mean time between failures
MTTR	mean time to repair
mV	millivolt(s)
mv	multivibrator
MΩ	megohm(s)
n	nano (10^{-9})
na	not applicable
NC	normally closed
(-) or neg	negative
NO	normally open
ns	nanosecond
opnl ampl	operational amplifier
p	pico (10^{-12})
para	paragraph
pcb	printed circuit board
pF	picofarad
pn	part number
(+) or pos	positive
pot	potentiometer
p-p	peak-to-peak
ppm	parts per million
PROM	programmablle read-only memory
psi	pound-force per square inch
RAM	random-access memory
rf	radio frequency
rms	root mean square
ROM	read-only memory
s or sec	second (time)
scope	oscilloscope
SH	shield
Si	silicon
serno	serial number
sr	shift register
Ta	tantalum
tb	terminal board
tc	temperature coefficient or temperature compensating
tcxo	temperature compensated crystal oscillator
tp	test point
u or μ	micro (10^{-6})
uhf	ultra high frequency
us or μs	microsecond(s) (10^{-6})
uut	unit under test
V	volt
v	voltage
var	variable
vco	voltage controlled oscillator
vhf	very high frequency
vlf	very low frequency
W	watt(s)
ww	wire wound
xfmr	transformer
xstr	transistor
xtal	crystal
xtlo	crystal oscillator
Ω	ohm(s)
μ	micro (10^{-6})

Section 8
Schematic Diagrams

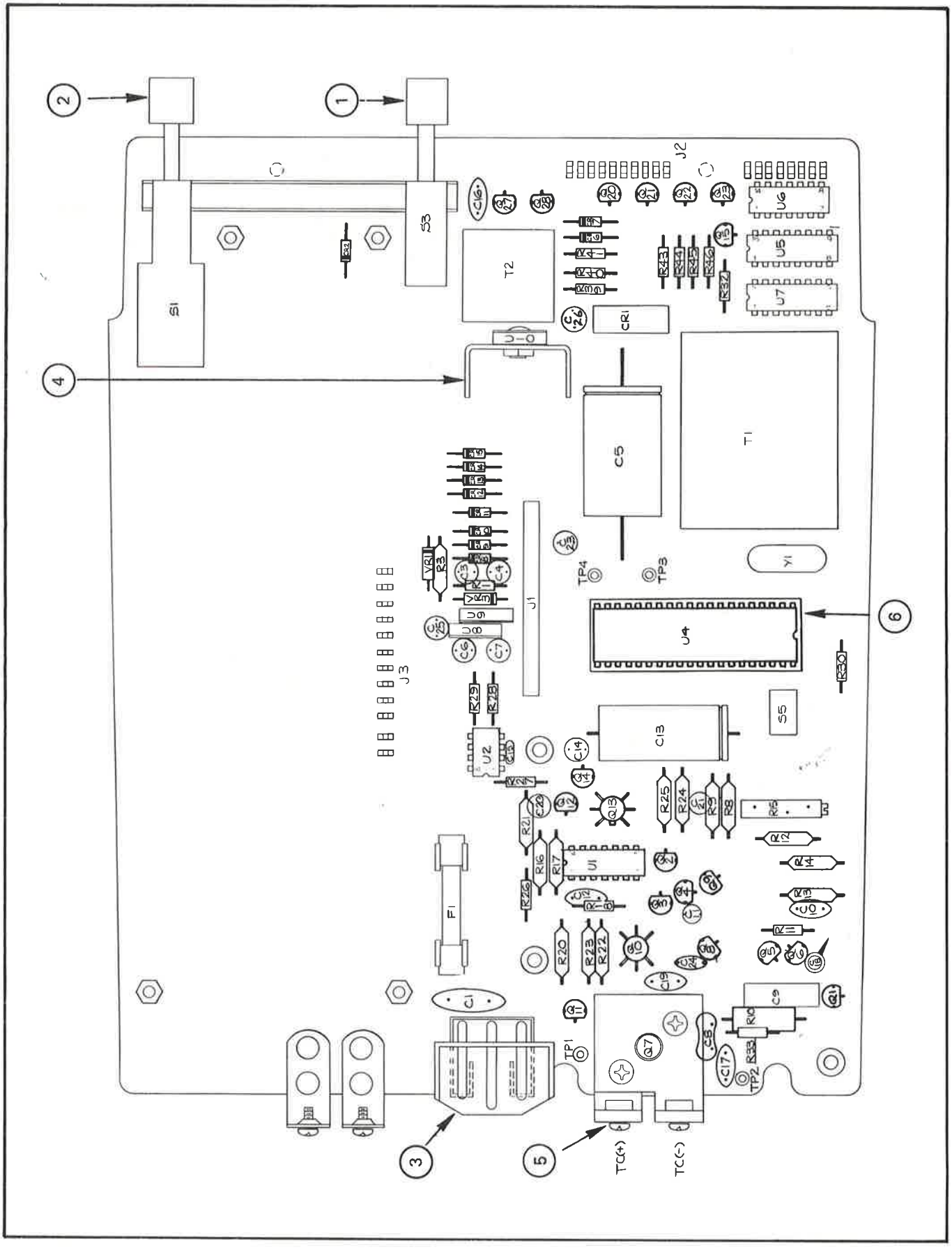


Figure 8-1. A1A1 THERMOMETER PCB ASSEMBLY COMPONENT LOCATION (2168A-1601)

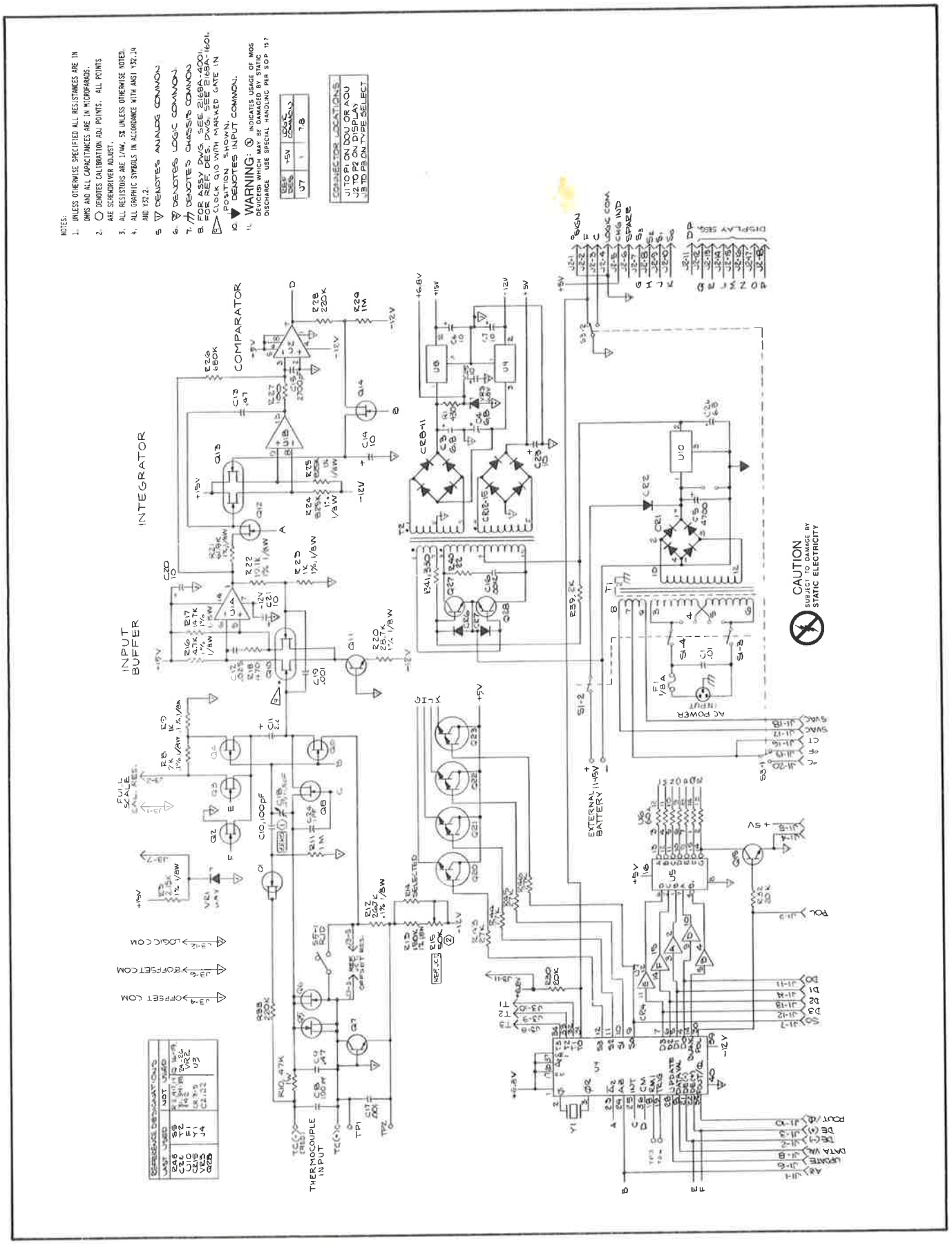


Figure 8-2. A1A1 THERMOMETER PCB ASSEMBLY SCHEMATIC (2168A-1001)

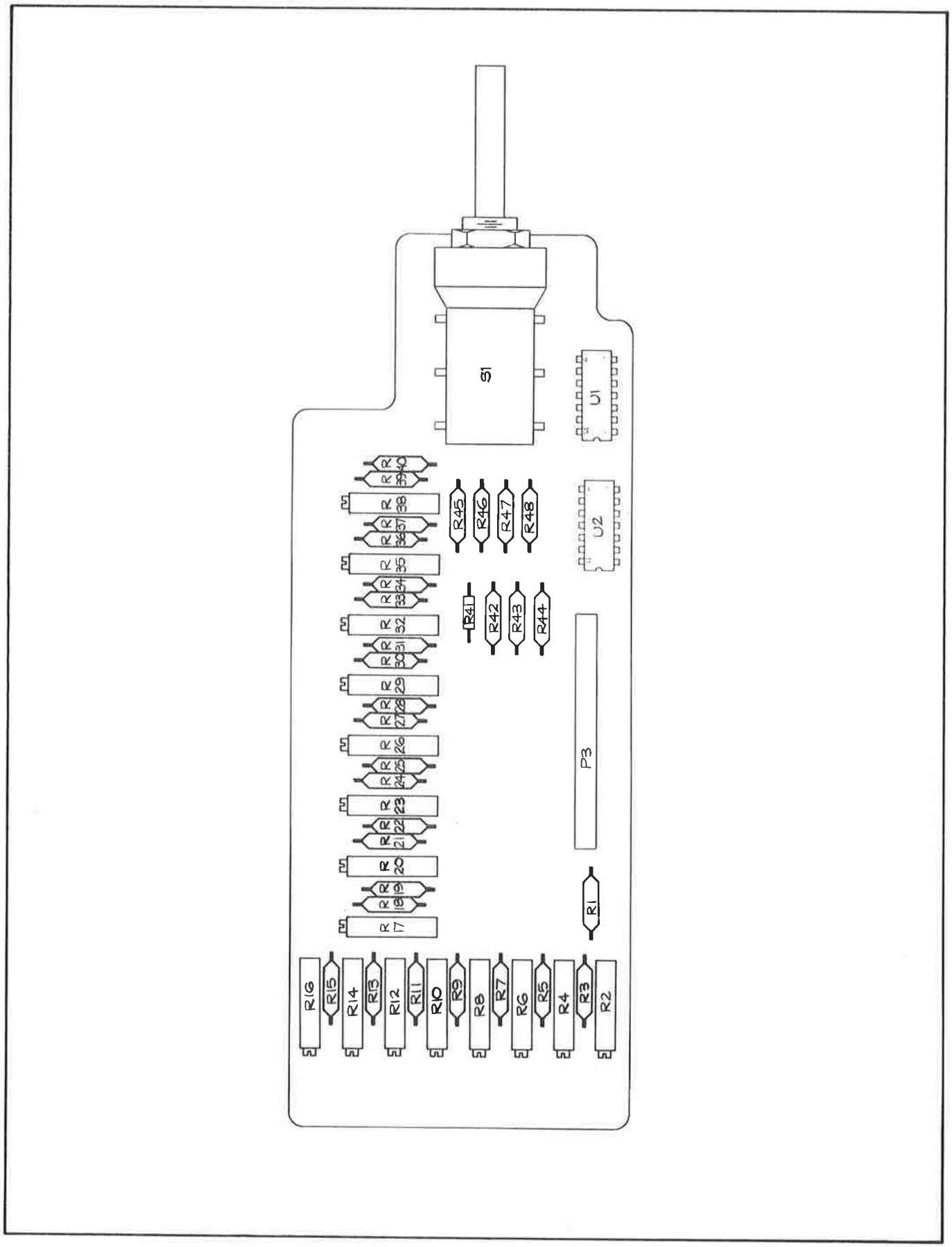
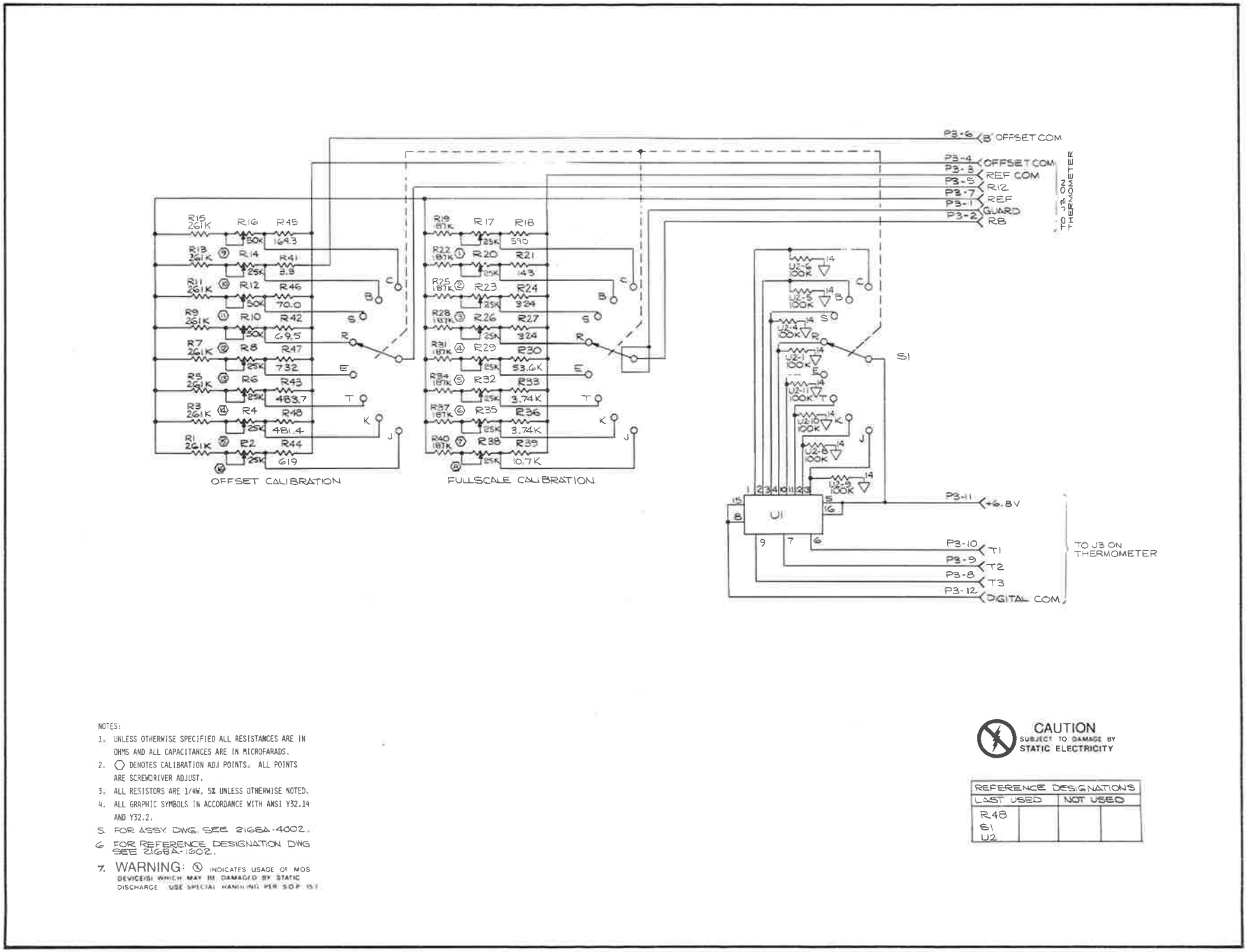


Figure 8-3. A1A2 TYPE SELECT PCB ASSEMBLY COMPONENT LOCATION (2168A-1602)



NOTES:

1. UNLESS OTHERWISE SPECIFIED ALL RESISTANCES ARE IN OHMS AND ALL CAPACITANCES ARE IN MICROFARADS.
2. ⬡ DENOTES CALIBRATION ADJ POINTS. ALL POINTS ARE SCREWDRIVER ADJUST.
3. ALL RESISTORS ARE 1/4W, 5% UNLESS OTHERWISE NOTED.
4. ALL GRAPHIC SYMBOLS IN ACCORDANCE WITH ANSI Y32.14 AND Y32.2.
5. FOR ASSY. DWG. SEE 2168A-4002.
6. FOR REFERENCE DESIGNATION DWG SEE 2168A-1602.
7. WARNING: ⊘ INDICATES USAGE OF MOS DEVICE(S) WHICH MAY BE DAMAGED BY STATIC DISCHARGE. USE SPECIAL HANDLING PER SOP 151

CAUTION
SUBJECT TO DAMAGE BY STATIC ELECTRICITY

REFERENCE DESIGNATIONS			
LAST USED		NOT USED	
R48			
S1			
U2			

Figure 8-4. A1A2 TYPE SELECT PCB ASSEMBLY SCHEMATIC (2168A-1002)

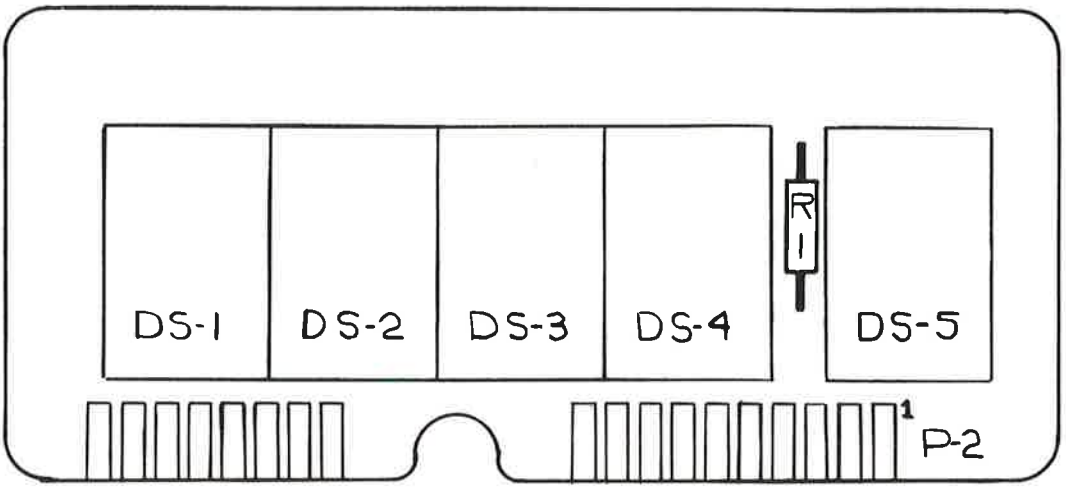
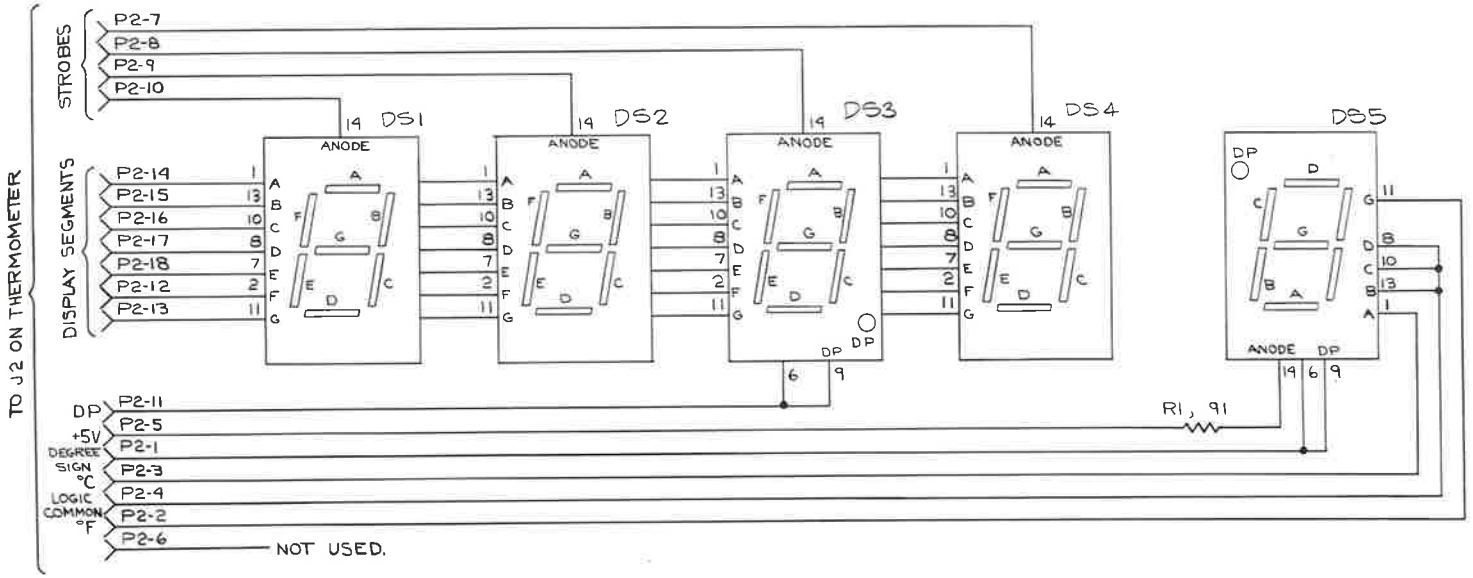


Figure 8-5. A2 DISPLAY PCB ASSEMBLY COMPONENT LOCATION (2165A-1603)



NOTES:

1. UNLESS OTHERWISE SPECIFIED ALL RESISTANCES ARE IN OHMS AND ALL CAPACITANCES ARE IN MICROFARADS.
2. ⬡ DENOTES CALIBRATION ADJ POINTS. ALL POINTS ARE SCREWDRIVER ADJUST.
3. ALL RESISTORS ARE 1/4W, 5% UNLESS OTHERWISE NOTED.
4. ALL GRAPHIC SYMBOLS IN ACCORDANCE WITH ANSI Y32.14 AND Y32.2.

Figure 8-6. A2 DISPLAY PCB ASSEMBLY SCHEMATIC (2165A-1003)